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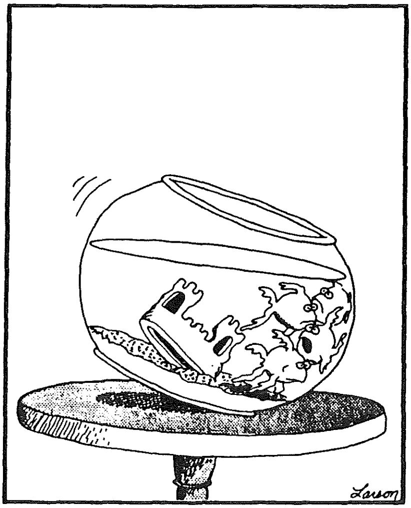
Report of the Working Group on Environmental Impacts of Mariculture

Dunstaffnage Marine Laboratory, Oban, Scotland, 19-24 April 1989



"Trim the bowl, you idiots! Trim the bowl!"

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Abstract

The Working Group discussed on the basis of national reports recent production trends, farm siting issues and ongoing research activities. Major sections of the report deal with the use of chemicals in mariculture and with site selection and monitoring issues. A general concept is proposed for the management of environmental impact, including various aspects from project descriptions to the identification of potential impacts. The Working Group also discussed wild and cultured fish interaction, in particular habitat interactions and diseases. Research priorities are listed together with the recommendations.

Résumé

Le groupe de travail a discuté sur la base des rapports nationaux les développements récents de la production, les décisions à prendre pour la séléction d'un site d'aquaculture et les activités de recherche en général. Le rapport traite aussi de l'utilisation des produits chimiques en mariculture. Une concéption est proposé de controller l'influence des fermes d'aquaculture sur l'environnement, inclus les differents aspects de la déscription du projêt à l'identification des dangers potentiels. Le groupe de travail a discuté aussi de l'interaction des poissons sauvages et de ceux sortant d'une ferme, en particulier l'influence de l'habitat et l'importance des maladies. Le rapport donne aussi une liste des éléments prioritaires de la recherche et des recommendations.

Introduction

The 1989 meeting of the ICES Working Group on "Environmental Impacts of Mariculture" was held at the Dunstaffnage Laboratory of the Scottish Marine Biological Association, Oban, Scotland, April 19 to 24 1989.

Participation

There were thirteen participants representing seven member countries:

Harald Rosenthal (Chairman)	Federal Republic of Germany
Richard Gowen (Rapporteur)	Scotland
Edward A. Black	Canada
James E. Stewart	Canada
Timo Mäkinen	Finland
Jaqueline Doyle	Ireland
Jan Aure	Norway
Arne Ervik	Norway
Ian M. Davies	Scotland
John G. McHenery	Scotland
Alan L.S. Munro	Scotland
Renger Dijkema	The Netherlands
Donald P. Weston	United States

During the meeting two sub-groups were formed for extended drafting sessions to discuss the "use of chemicals" (chaired by D. Weston), and "site selection and monitoring" (chaired by Edward Black).

Guests

Dr. Tomas Pearson	S.E.A.S., Ltd., Scotland
Dr. Brendan O'Connor	Galway, Ireland

Terms of Reference for the 1989 Working Group meeting

The 1988 Working Group report and the recommendations formulated therein were discussed by ACMP during its midterm meeting in Copenhagen. The ACMP noted that there are many more aspects which should be addressed by the Working Group and for which other problem-solving strategies might be suggested. While it is possible to formulate unifying concepts about the practice of cultivating aquatic marine organisms, aquaculture is carried out under widely differing geographic, climatic and ecological conditions and many important concepts may be limited to the specific conditions where they arise. The ACMP felt that in view of the large number and diversity of topics being considered, the 1989 meeting should be extended to a 5 day meeting. The recommendations of the Working Group were adopted at the 76th Statutory Meeting of ICES. For the second meeting of the Working Group in Oban the terms of reference were:

(a) review ongoing research programmes on environmental issues related to mariculture, to compare results from various countries to facilitate transfer of information and identify research priorities,

(b) discuss the value of using specific parameters and techniques for monitoring strategies and continue the preparation of a technical report,

(c) collate information on uses of chemicals and prepare a technical report to include (1) a list of chemicals used within the various forms of mariculture, (2) quantities used within member countries, (3) synthesis of information on the environmental effects of these chemicals,

(d) further assess the development of models for quantifying environmental impacts, holding or carrying capacity,

(e) continue an assessment of criteria for site selection and the preparation of a section on site selection for inclusion in a proposed technical report.

Discussion of National Reports

It was decided to attach National Reports as Appendix 1 to this report without detailed discussion in order to allow maximum time for drafting and discussion of sections to be prepared for the various technical reports. Some important developments in various countries are worth mentioning here:

(1) Production trends

In most of the member countries (Canada, Denmark, Finland, Ireland, Iceland, Norway, Portugal, United Kingdom) finfish mariculture production showed a remarkably rapid growth rate in 1988. The prospects for 1989 seem to be even greater for a few countries. The trend in coastal cage farming is towards larger units installed in more exposed sites, and employing lower stocking densities. Shellfish production is relatively stable in most of the major producing countries (Netherlands, Portugal, Spain), but on the rise in Ireland (extensive farming) and Scotland.

(2) Farm siting and monitoring

The issues related to siting farms and to monitoring practices were briefly addressed in several country reports. They were mainly discussed in relation to the preparation of the various sections in preparation for the draft technical report on "Site selection and monitoring" and the reader is referred to the respective section of this report.

(3) Use of chemicals

Discussing the wider use of chemicals, information was presented by several countries, describing the trend in usage in relation to overall mariculture production. Some data were also provided through the Working Group on Pathology and Diseases of Marine Organisms.

Although it is difficult to distinguish in every case between marine and freshwater applications, the overall figures indicate certain trends in marine uses with a wide range of fluctuation. The trends in some countries seem to be related to the overall production trend and to special events (e.g. unexpected disease outbreaks, unusually warm summers). For example, the recent decline in the use of antibiotics in Norway in 1988 suggests that the development and use of vaccines against the Hitra-disease and improved husbandry were effective in reducing the quantities applied; there seems to be further room for improvement.

Recent trends in Finland indicate that under certain management schemes it might be possible to reduce the amount of drugs per unit weight of fish produced. The listing of chemicals and total amounts used in various countries are presented in Tables 2 and 3.

(4) Research activities

The following is an updated version of the table presented in last years' report. The list includes most of the earlier reported projects, a number of new projects and omits those which have been terminated. Information is provided on the progress made.

Table 1

Studies related to environmental aspects of mariculture (Recently Completed and on-going)

Project Description	Completion Date	Country and References, if any
New projects are indicated by an asterisk (*)		
Investigation into the effects of fish cage culture on: benthos, hypernutrification, eutrophication, wild fish populations, and bacteria. Laboratory experiments to investigate the nutrient load in relation to temperature, food type and fish size.	Dec. 1990	Denmark
(no information on its progress in 1988/89 was received)		
Algarve: Environmental studies at Faro-Olhao sea lagoon "Ria Formosa". Regular monitoring of phyto-plankton; changes in bacterial population inside and outside the lagoon and in bivalves; sediment - water column exchange of oxygen and nutrients; studies on PCB in cultured species and wild populations; studies on water exchangerates; studies on the pathology of clams and otherbivalves; eutrophication, bacteria, chemicals.	3 years	Portugal
(no information on progress received)		
Mondego estuary: Regular monitoring of phyto-, zoo- and ichthyoplankton, and of physical conditions; studies on water exchange rates and fish pathology.	2 years	Portugal
(no information on progress received)		

Development of a model for regional planning and site selection for mariculture in the coastal zone. The aim is to avoid brackish areas prone to eutrophication effects caused by net cage culture. Measurements of bottom dynamics, hydraulics and biological parameters in the vicinity of fish farms be made.	1989	Finland Ervik, et al., 1987 Håkansson et al., in preparation Koivisto and Blomqvist, in print

(the publication by Koivisto and Blomquist is cited in the literature list; a further extended joint publication by Håkanson, L., Ervik, A, Mäkinen, T., Møller, B, 1988 is available entitled "Basic concepts concerning assessment of environmental effects of marine fish farms": see literature list. The final report should be available by 1990.)

Calibration and validation of two ecosystem simulation models with which the carrying capacity for mollusc shellfish culture can be assessed in the Waddenzee and the Oosterschelde estuary.	1991*	Netherlands

(first reports available: Smaale and Van Stralen (1989), NIOZ (Netherlands Institute of Sea Research, see references)

Research to assess the influence of two types of mollusc dredges, used for the seed fishery for mussel cultivation, on the substrate of natural intertidal mussel beds.	1991*	Netherlands
Measurement of in situ production of nutrients and consumption of particulate food by mussels and the communities on cultivation plots.	1992*	Netherlands
Research into suitable sites for mussel cultivation in the Oosterschelde in relation with current velocity and food availability.	1991*	Netherlands
Development of a model for regional planning and site selection of mariculture in the coastal zone. The aim is to avoid brackish areas prone to eutrophication effects caused by net cage culture. Measurements of bottom dynamics, hydraulics and biological parameters in the vicinity of fish farms are made.	1990	Finland

(The project is continuing and the final report will be published in 1990 after the termination of the project.)

Antibiotics in farmed fish, wild fauna and sediment, and degradation rates of chemicals	1988	Finland Björklund et al.

Changes in sediment chemistry and benthic infauna beneath a large salmon cage farm (160 pens, 620 t per year). In addition to routine measurements of species composition and abundances, the effects of organic enrichment are being measured by shifts in the vertical distribution of biomass within the sediment, gradients in average individual size, and the relative proportion of various feeding guilds. Initial results indicate impacts extending at least 150 m from the farm site.	March 1989	United States

(Manuscript in preparation - publication anticipated in late 1989).

A newly developed model which predicts the dispersion of feed and faeces from salmon net-cages is being tested at two Puget Sound farm sites. There are two principal goals: 1) to field verify the model predictions of accumulation rate in the surrounding area; and 2) to determine the effect of any given accumulation rate on the benthic fauna. The model will ultimately be used for site selection, to determine the probable areal extent of benthic impacts.	Oct. 1987	United States

(Study completed in late 1988; report available since early 1989: Weston, D.P., Gowen, R.J., "Assessment and prediction of the effects of salmon net-pen culture on the benthic environment." Washington Dep. Fisheries, Technical Report 414(Ref.M88-2), November 1988,62pp.)

Interactions between net-cage culture and phytoplankton blooms are being examined in the laboratory and at four Puget Sound farm sites. The work will include: 1) laboratory investigations on the causes of fish mortality when exposed to *Ceratium* and *Chaetoceros*; 2) studies of environmental factors accompanying blooms; and 3) field studies on the vertical distribution of problem species and the effectiveness of mitigation techniques.	Dec. 1991	United States

(Project delayed. Now scheduled to begin in January 1990).

A study to evaluate the potential accumulation of antibiotics in shellfish living in the vicinity of fish culture sites. Oysters were hung directly under a net-cage throughout a 10-day period of oxytetracycline treatment. Analytical interferences have, to date prevented reliable quantification of antibiotic residues in the samples.	Oct. 1987	United States

(Study completed. Abstract published as J.F.Tibbs et al. 1988, see reference listing).

A study to determine if salmon culture either introduces bacteria or encourages the prolif-	Nov. 1987	United States

eration of native strains that might represent a threat to nearby shellfish or their human consumers.

(Study completed but no report has been prepared).

Initial models for the carrying capacity of a water body for shellfish culture were found to have limitations caused by lack of knowledge regarding input parameters. Experiments will be continued 1979,1988.to determine the effect of seston quality (various uni- and mixed algae cultures used as food - inclusiveof toxic microalgae) abd quantity as input parameters for models.	Ongoing -	Eastern Canada Wildish and Krist-manson,
An interdisciplinary study of physical and chemical oceanography involving scientists at the Bedford Institute of Oceanography and the St. Andrews Biological Station. It will also include benthic, phytoplanktonic and microbiological observations and be aimed at the development of a capacity model for salmonid culture in Lime Kiln Bay.	Ongoing - (Expanded in 1989)	Eastern Canada

(Technical Report available from Dep. Fisheries and Oceans, see Wildish et al., 1988)

The effect of blue mussel culture on the benthic environment is under investigation in Nova Scotia and Prince Edward Island (G.Daborn, M.Brylinsky)	Ongoing	Eastern Canada
The cause of summer kill in cultured blue mussel	1989	Eastern Canada
Phytoplankton profiles including identity and abundance of species and factors involved - nutrients, temperature, oxygen, stability of water, chlorophyll, productivity and toxin production in and around shellfish culture sites contrasted with non shellfish sites. - Three year programme. All regions in East coast Subba Rao, Wildish, Worms, Cembella and Schwinghammer.	probably1992*	Eastern Canada
The potential for transfer of therapeutants from fish feed to nearby oysters is under investigation. Laboratory studies will examine therapeutant uptake by oysters and potential transport mechanisms. A field study will assess possible oyster contamination near fish farms.	proposed for 1989	Western Canada

(Study delayed until 1990)

Algal problems cost the British Columbia salmon farming industry \$3.800.000 in 1987. In order to give industry advance warning of harmful algal blooms and to assist researchers studying these occurrences, an industry based warning system has been devised. Its effectiveness is under study.	Ongoing	Western Canada

(An internal report compiles information derived from industry based phytoplankton sampling to detect changes in abundance and species composition. Insurance companies estimate several million dollar product saved by this programme).

A study is being made of the water quality in a commercial salmon net cage to determine if there is any evidence of isolation of the culture water from the surrounding environment. It examines empty cages, stocked cages, clean and fouled cages.	1989	Western Canada

(Master Thesis completed by Steven Garmican, Univ. British Columbia, Vancouver. There is evidence of temporary oxygen depletion within cages relative to the surrounding environment. Currents, slack tide, time of day, cage configuration are contributing factors.

The Sechelt Inlet system is composed of three fjords all emptying out over a single shallow sill. The industry has proposed to farm 3800 tonnes of salmon in the system. To identify whether this will have any effect on the water quality of the system, a biannual baseline survey on water quality over a three to five year period has been initiated. The study will monitor an progressive change in water quality at the farmsites and will also investigate how this relates to water quality in the central water body.	1991	Western Canada

(The anticipated production mentioned above will probably be reached in 1990. The surveys are done twice a year prior to spring bloom and in late summer. Sampling is done at 4 existing farm sites, 3 nearshore control stations and 6 mid-channel stations. The first reports are expected to be completed during early 1990).

The content of phosphorus in ten commercial brands of feed as well as the metabolic wastes from rainbow trout were investigated. By sequential extraction of phosphorus it was possible to determine the readily soluble fraction. Most feed brands had phosphorus concentrations in excess of 1% dry weight. About one-third of the phosphorus in both feed and faeces was readily soluble in water.	1986	Sweden
The composition of various types of dry feed has been investigated. It was recommended that the fat content be increased up to 25% and the carbohydrate content be decreased, both for nutritional and environmental	1987	Sweden

reasons. The discharge of nutrients from cage culture can be reduced by 30-40% in the future by changing feed composition and reducing wastage.		
The coastlines of the Bothnian Bay and Bothnian Sea are characterized by many paper mills and mariculture operations. The discharge of nitrogen and phosphorus to the Bothnian Bay from Swedish mariculture operations is 0.6 and 1.9%, respectively, of the total Swedish contribution. In the Bothnian Sea, the corresponding percentages are 0.1 and 0.2%.	1987	Sweden
This study quantified the pollution by persistent organic substances, metals, nutrients and oil. It was suggested that if all licences given to Swedish aquaculturists were fully utilized, the industry would contribute 6% of the total phosphorus load.	1986	Sweden
Investigation of the impact of marine fish farms on the receiving water body. Keywords: nutrition salts, sedimentation, material, benthic infauna.	1987	Norway Aure, et al., 1988
Fate of organic waste from marine fish farms. Keywords: sedimentation, decomposition, ebullition, distribution in the marine food chain.	1990 (?)	Norway
Develop a data base for storage of sensor data from fish farms, in order to obtain time series for scientific analysis.	1989*	Norway
Develop methods for treatment of fish farm wastes. Describe waste spreading and persistence on the sea floor. Assessment of environmental impact at fish farm drugs. Study at microbiologiocal processes in fish farms deposits on the sea floor.	1990*	Norway

(A first report available in Norwegian language: Vethe, Ø. 1988. Fullskala forsøksanlegg for kompostering fiskeoppdrettsavfall.- GEFO -rapport Nr. 61.031. (Inst. for Georesources and Pollution Research).

Isolate and investigate potentially toxic flagellates (esp. *Chrysocrhomulina* sp.).	1991*	Norway Prof. E. Paasche,
	Univ. Oslo	
Studying daily sedimentation rates, studying effects from mud-dredging.	1989*	Norway

Study central parameters (or growth rate, oxygen consumption, BOD) from rearing of Atlantic salmon in land-based tanks.	1990	Norway Rogaland Research Institute

(several preliminary reports are available in Norwegian).

Investigations of the effect on fish farms of crude oil exposure. A project studying pollution effects on aquaculture.	1989	Norway
Development of low-pollution fish feeds.	1989	Norway Rogaland Research Institute
Develop of an efficient tool of coastal zone planning (LENKA).	1989	Norway ICES 1988/F:11

(Continuation and expansion of other components of the LENKA-project mentioned in this listing)

Investigation of the effect and fate antibiotics.	1991	Norway

(Some results of these studies are included in ICES Doc. C.M. 1988/F:14, see full citation in Literature list).

Effect of local discharges of nutrients and organic matter from marine fish farms upon oxygen 1988 conditions in deep water of sill fjords.	Autumn 1988	Norway Stigebrandt,etal. Aure and Stigebrandt, 1988a; 1988b

(Final report available in Norwegian language from the author; additional papers appeared in scientific journals; see literature list)

Level of drugs in farmed fish, wild fauna and sediment, and degradation rates of the chemicals.	1990*	Norway 3 reports
Investigation into resistant microflora in the sediment beneath fish farms.	1990*	Norway
Investigation on feeding behaviour by hydro-acoustic detection of feed waste.	1989?	Norway Juell, 1988
Development of low density dry feeds	?*	Norway
Investigation of effects of water quality, especially ammonium, on salt and water balance in salmonids.	1990?*	Norway

Through a project known as LENKA, an efficient and standardized methodology for coastal zone planning is under development. The programme is intended to identify areas suitable for mariculture and avoid areas of probable use conflicts.	1989	Norway several internal working documents Norwegian
The parasitic biology of *Caligulus elongatus* and *Lepeophtherius salmonis* on farmed salmon untreated for infestation. The objective of this study is to find a method to control sea lice populations without resorting to environmentally damaging pesticides. Information is being collected on the natural rhythm of infestations and parasitic intensity, and population turnover time at different temperatures. A thorough understanding of these processes will, it is hoped, enable more effective physical or biological control of epizootics of these parasites.	Ongoing	Ireland
The detection of Dichlorvos in the marine environment. Its effects on marine ecosystems and lethal and sublethal effects on fish, crustaceans and bivalves.	Ongoing	Ireland

(C. Duggan, in press, Sublethal effects on Patellas vulgalta at 10^{-10} detected)

Studies of Dichlorvos toxicity on crustacea.	Ongoing	Ireland

Toxicity to Palaemonetes varians detected at 0.01 ppm (10^{-8}). B. Ottway (1989) personal communication. Regional Technical College Galway)

Analytical techniques for Dichlorvos in fish and water.	Ongoing	Ireland
The impact of tributyltin (TBT) residues on mollusc spawning and survival.	Ongoing	Ireland
Uptake of antibiotics from salmon farms by edible molluscs.	1989	Ireland

(No information on progress of the project has been received)

Preliminary trials on the efficacy of Ivermectin print,in oral therapy for control of parasitic copepods of Atlantic salmon.	1988	Ireland, Publ. in Bull. Assoc. European Fish. Soc.

(Report should be available before the end of the year)

Laboratory studies of the toxicity and sub-lethal effects of dichlorvos and possible alternatives for sea lice treatment. Field and laboratory investigations of the impact of dichlorvos treatment on non-target organisms, including adult and larval molluscs and crustaceans.	Ongoing	Scotland
Desk and experimental investigations of possible alternatives to dichlorvos in sea lice treatment including studies of the basic biology of the parasites concerned.	Ongoing	Scotland
Recovery of environments exposed to TBT: as part of an on-going monitoring of the impact of TBT on marine life. Imposex was adopted and *Nucella* is now being used to monitor the recovery of sites where impact had been found. The biological effects techniques are being supported by chemical determination of organotins.	1989	Scotland
A study of the survival of *Aeromonas salmonicida* in sediments	1990	Scotland
An investigation into hypernutrification eutrophication with the aim of determining the holding capacity of sea lochs. Hydrographic and modelling studies of sealochs. The impact of farming operations on benthic communities.	Ongoing	Scotland

(Turrell and Munro, 1988. Further reports expected next year)

The release of dissolved forms of nitrogen from sediments enriched by fish farm waste.	1988	Scotland

(Project has been finalized, resulting in a Thesis prepared by F. Johnson; available from Stirling University, Scotland)

Site Selection and Monitoring

Management of the Environmental Impact of Mariculture

The Working Group recognized that an assessment and synthesis of many factors (environmental, social and economic) has to be undertaken prior to approval of the establishment of - as well as during - a mariculture operation. The flow diagram outlined below illustrates one way in which such an assessment could be undertaken.

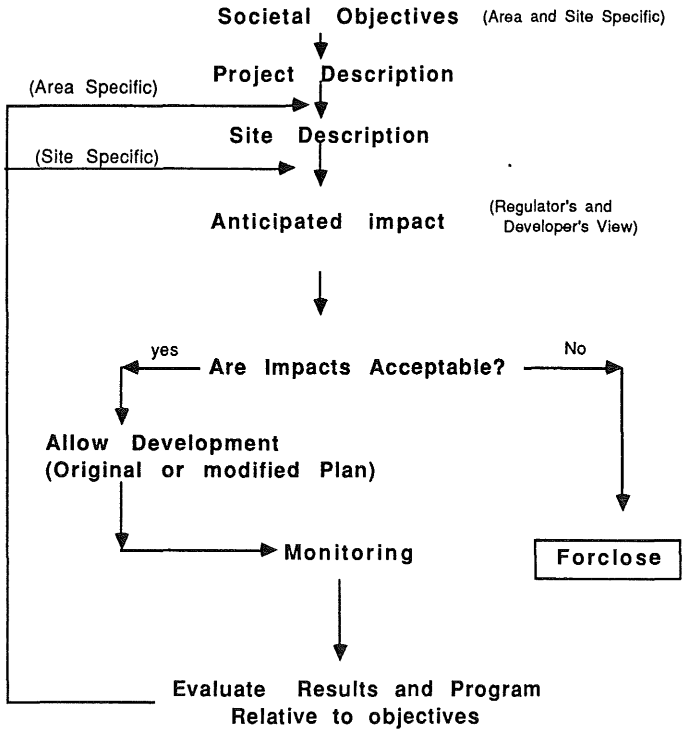

Figure 1: Flowchart on principle procedures for the evaluation of environmental impact of mariculture

The Working Group discussed its role in providing advice in such decision making, particularly in relation to the concept of "an acceptable level of environmental change", resulting from a specific environmental impact. It was agreed that for most environmental impacts the ecological basis for establishing "acceptable levels of change" have not been formulated. For this reason, and because issues other than environmental ones may be included, the Working Group agreed that the responsibility for setting "acceptable levels of change" resides with the governmental and regulatory authorities of each member state. The Working Group therefore considered that its role should be restricted to identifying possible environmental impacts providing methods on approaches for quantifying and monitoring these and advice on how to minimize such effects.

Some ecological impacts of mariculture (e.g. organic enrichment of the benthos) have been studied in detail (Mattson and Linden, 1983; Brown et al 1987; Tenore et al. 1982) and mathematical models have been formulated which can be used with caution as tools to estimate the extent of impact prior to the establishment of a mariculture operation in some situations. It should be recognized that current models incorporate assumptions which are not necessarly valid in all situations. As such these models should be regarded as aids to assessing environmental impact but not providing definitive statements regarding the impacts. Furthermore, some environmental impacts must be regarded as potential since the perceived threats to the environment are based on current understanding of coastal marine ecosystems rather than data derived from research specific to mariculture. Examples of this would be hypernutrification and eutrophication resulting from the release of dissolved nutrients from fish farms. In such cases monitoring specific parameters (for example, dissolved inorganic nutrients (nitrate, ammonium and phosphate) and phytoplankton biomass are the only means of assessing whether environmental change is occurring. As a result there is for environmental protection a need to assess the environmental impact of mariculture operations. In addition it is known that some environmental change can affect the viability of the mariculture operation itself. Thus additional monitoring (for example, organic enrichment of the sediment) may be required to identify environmental changes which could reduce production potential.

The careful selection of a site will minimize specific impacts on coastal marine ecosystems and reduce the risk of negative feedback affecting the production potential of the operation. Site selection and monitoring can be regarded as methods of managing the environmental impact of mariculture and the Working Group decided that both topics should be combined under the heading "management of the environmental impact of mariculture". The format given below was adopted as the format for a draft technical report.

1. Project description
2. Area and site description
3. Identification of potential impacts
4. Conditions and constraints on the proposal
5. Monitoring
6. Evaluation

The Working Group noted that the topics listed above are also an integral part of the scientific components of the LENKA and CRIS coastal zone management programmes of Norway and western Canada, respectively. Information on the progress of these two programmes was reviewed.

The following gives an outline of factors which the Working Group agreed should be included in each subsection of a proposed technical report on "Management of the environmental impact of mariculture".

(1) Project Description

Project type :

- fin fish; crustacea; molluscs (bottom or suspended culture); algae.

production scale:

- area covered; tonnage produced; production cycle; standing biomass.

Wastes:

- physical state and composition.
- discharge (point or diffuse source; time of discharge).
- quantities of waste (including processing, human waste)

Biological and physical requirements of the culture organisms

(2) Area and Site Description

Physical:

- coastline morphology and bathymetry;
- sediment particle size analysis;
- temperature; salinity, flushing time of the basin;
- current speed and current patterns; wave height;

Chemical:
- redox potential and organic content of the sediment;
- dissolved oxygen;
- dissolved inorganic nutrients; pollutants.

Biological:
- Natural resourses (fisheries, macroalgae);
- wildlife (proximity and importance of wildlife communities);
- presence of sulphur-oxidising bacteria (e.g. *Beggiatoa)* on sediments;
- phytoplankton.

(3) Identification of potential impacts

- assessment of holding and carrying capacity
- Organic enrichment of the benthos
  (changes in sediment chemistry and benthic macrofauna);
- hypernutrification and eutrophication;
- changes in turbidity; oxygen supply; ammonia.

These issues are discussed in detail in ICES Cooperative Research Report No 154, 1988.

(4) Conditions and constraints on the proposal

-modification of the scale of production
-collection and removal of waste
  (uneaten food, settled solids, mortalities)
-preventive measures to limit the impact on wildlife (birds and mammals).
-identification of buffer zone between operations.
-prevention of escapes from the culture operation.

(5) Monitoring

-Purpose of monitoring
  -environmental protection.
  -farm management
  -research

-Establishment of suitable monitoring programmes
  -for land-based systems
  -for sea-based systems
  -Role of mariculturist and government agencies in monitoring
  -what parameters to measure;
  -frequency of monitoring,
  -spatial deployment of monitoring stations
  -Data collection and methods of measurement

The rational behind these headings was presented in the ICES document C.M. 1988/F:32.

(6) Evaluation

- -Review of monitoring programmes
- -Evaluation of the data for regulatory purposes, farm management, and research.
- -Identification of trends in relation to established environmental quality standards (e.g. faecal coliforms).

A number of documents relating to monitoring and site selection were tabled and discussed (these are included in the updated literature list). Material from these sources will be reviewed for inclusion in the proposed Technical Report on "Management of the environmental impact of Mariculture".

Some recent developments in this field were considered by the Working Group and the conclusions are presented below:

Techniques for the rapid acquisition and analysis of environmental data

Evaluation of sediment profile imagery

Dr. Brendan O'Connor (Ireland) was invited to present information on the function and the capabilities of a sediment profile imaging technique recently employed in an assessment of the impact of mariculture in an embayment in Ireland. The particular profile imaging technique used in Ireland is known as REMOTS® (Remote Ecological Monitoring Of The Seafloor). It is essentially an inverted periscope or optical corer which gently transects the bottom in the vertical dimension. The upper 20 cm of the sediment column, as seen in profile, is then photographed in high resolution with a film camera. After each image is taken, the camera is raised two or three meters off the bottom and redeployed for taking another image ("sample"). Typically five replicate images are taken at each station within a period of about 5 minutes. Actual samples of the bottom are not recovered. Rather, the photographed profiles of the bottom are recorded on film for subsequent computer image analysis. Physical data acquired in the analysis include measurements of redox potential discontinuity, grain size, methane pockets, etc. Sediment profile imaging technology is now being used for mapping organic enrichment gradients and has recently been used to map organic loading associated with mussel-raft cultures in Galicia, Spain. Because of the need to discuss possible means of monitoring it was felt appropriate to familiarize the Working Group with new approaches on environmental monitoring in order to discuss the pros and cons of such techniques for monitoring environmental impacts of mariculture. An extended discussion took place after the presentation of the technique and the results obtained.

The Working Group also invited Dr. Tom Pearson of the Dunstaffnage Laboratory to comment on the utility of sediment profile imagery in assessing the impact of organic enrichment on benthic environments. Dr. Pearson was very optimistic about the applications of the technique and felt that its full potential had not yet been exploited. Its principal advantage was the dramatic reduction is sample processing time permitted by photographic "sampling" as compared to traditional benthic sampling by grab or coring techniques. Dr. Pearson believed, however, that the use of the procedure requires a thorough knowledge of the benthic communities in the habitat of concern based on prior or concurrent traditional sampling. Sediment profile imagery can be employed only in those areas where there is justification for believing that its inherent biological assumptions regarding the effects of organic enrichment are valid.

Based upon the presentations of Drs. O'Connor and Pearson, as well as comments of its own members familiar with sediment profiling systems and experienced in benthic impact assessment, the Working Group concluded that the advantages of the technique included:

1) A reduction in sample processing time from the several days required for traditional benthic sample processing to less than an hour for visual and computerized image analysis.

2) The capacity to include many more samples in a site survey than would ordinarily be possible because of the reduced sample processing time required by sediment profile imaging.

3) The acquisition of information in the vertical dimension on both chemical and biological parameters. Such data are often not collected by grab sampling, although they are often utilized by those sampling with coring devices.

4) The potential for impact assessment in real time by exploiting video technology in a profiling system.

The technique is not, however, without its disadvantages in comparison to traditional sampling. Some of the disadvantages are inherent to the approach while others are related to the fact that the technology is relatively new (about 10 years) and not widely available. Shortcomings of the technique include:

1) The fact that biological information is obtained largely by inference (e.g. depth of redox potential discontinuity, burrows, feeding voids) rather than by actual observation or measurement of the biota. Only a very small proportion of the animals present at a site are actually visible in the photographic images and support by ground-truth data is required.

2) The total reliance of the system on conceptual successional models which may or may not be valid in environments other than for which they were developed.

3) The current high cost of the system which makes its use feasible only when the costs can be spread over a great number of samples.

4) The limited availability of profiling systems compared to traditional benthic sampling). Few sediment profiling units are now in use and, to the knowledge of the working group, there is only a single proprietary image analysis software package now available. Other image analysis software is under development and the technique could be used without computerized image analysis.

The Working Group concluded that traditional benthic sampling, when properly executed and interpreted, is capable of revealing much more about the response of the benthos to organic enrichment than is sediment profile imagery. The data benefit, however, comes at a considerable cost in terms of the required sample processing time. In their present form, sediment profile imaging techniques are valuable tools for providing a rapid overview of organic enrichment of a large area, such as in a reconnaisance survey. It is recommended, however, that use in a particular area be complemented by traditional macrofaunal sampling in order to validate the biological assumptions of imaging techniques. The potential and general applicability of the techniques require further research and development. Profile imaging techniques, in their present form, are not suitable for impact assessment at a single farm when sampling coverage of only a small area is desired and when both imaging and conventional sampling is not feasible.

Kiel Seston sampler

Another relatively new technique to monitor suspended solids under and around water-based culture systems is a modification of the Kiel Seston Recorder. This instrument is a controlled unit for high resolution *in situ* measurements of type-specific, complex particle concentrations in water. The samples are welded *in situ* between two foils. The samples can be analyzed immediately or at a later date without any further preparation. (See Figure 2.) This technique has not yet been widely used under or near net cage farms. It has, however, been proposed for this application and a modification of the original design is presently under laboratory testing in Norway and Germany.

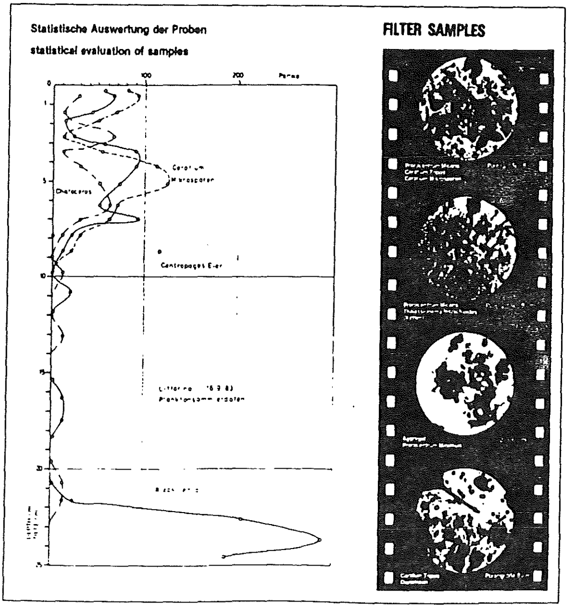

Figure 2: Example of a preserved sample series collected with the Kiel Seston sampler, a modified version of which being tested for its applicability in monitoring aquaculture sites for both sedimentation and disease agents.

Modelling

Dr. Alan Munro (Scotland) described to the Working Group a hydrodynamic model being developed for application in Scottish lochs (identical to that discussed at the ICES Statutory Meeting in October 1988, F:36). It is a simple two compartment box model with a net out-going flow in a stratified surface layer and an incoming flow of bottom waters. The model has been used to predict the concentration and dispersal of water soluble aquaculture wastes (nutrients, antibiotics) and the movement of micro-organisms from a farm, modelling the microbes as neutrally-buoyant particles carried passively in the out-going surface waters. At the present time the model has been used only for computer simulations of waste dispersal from a hypothetical farm; the major objective at this stage of development is to assist in the design of field studies. The Working Group recognised the potential of approaches such as this in site selection to establish holding capacity or the optimal location of farms within a water body. The usefulness and reliability of this and other similar and widely available models is restricted by their failure to incorporate the true degree of variability in the physical environment (e.g. depth of stratification) and their exclusion of critical but unquantified biological parameters (e.g. relationship of nutrient concentration and primary productivity, to factors other than pathogen density which determine probability of infection).

Drs. Richard Gowen (Scotland) and Donald Weston (United States) presented a further assessment of a sedimentation model previously described in the Working Group's April 1988 report. The model incorporates the variables of water depth, current velocity and direction, and quantity of feed provided to estimate the probable magnitude of organic carbon loading to the seabed. It is useful in site selection in order to predict the spatial extent of the effected area as well as the magnitude of loading directly beneath the farm, an estmate which may be of particular interest to the farmer. The model was recently tested at two farm sites in the northwestern United States. At the first site it performed very well, accurately predicting both the rate of organic carbon accumulation (as measured by sediment traps) and the spatial extent of the affected area. Those areas which the model predicted would receive the greatest amount of feed and faeces were the same areas which were found to have the greatest degree of sediment enrichment. At the second farm the predictions were less accurate; conditions may be complicated by a significant degree of resuspension, a parameter not considered in the model. A report of the model tests has been prepared and is listed as Weston and Gowen (1988) in the "Literature consulted" section of this document.

Governmental requirement for environmental assessment

It was brought to the Working Groups attention that Governments of some ICES member states require environmental impact assessment of aquaculture operations. For example, under EC Directive 85/337/EEC, member states are required to take measures to obtain assessments of the effects on the environment of fish farm developments. In the U.K., for example, the Environmental Assessment (Salmon Farming in Marine Waters) Regulations 1988 (Stat. Inst. 1218) require that, if the Crown Estate Commissioners consider that a proposed salmon farming development is likely to have significant effects on the environment, the applicant should prepare an environmental statement.

The Working Group considered that it would be an aid in the drafting of a proposed technical report on "Management of the environmental impact of Mariculture", to review similar national legislation from other countries. With this in mind the Chairman asked each member of the Working Group to obtain details of legislation for environmental monitoring for discussion at the next meeting. Two examples of legislative documentation (United Kingdom and British Columbia) are provided in Annex 4A and B.

Chemical usage in mariculture

The Working Group was requested to prepare a technical report on the use of chemicals in mariculture. The report is expected to include a list of the chemicals used in member countries, the quantities used, and information on the environmental effects of these chemicals. It was recognized that a report of such scope is a difficult undertaking, but is necessary to:

1) illustrate the paucity of information on the environmental fate and effects for many of the compounds in common use;

2) increase awareness of the potential impacts of chemical use on the surrounding environment; and

3) illustrate the potential negative effects on the farm itself which may result from improper or excessive chemical usage.

There was some initial discussion of the scope of this technical report, and which segments of the mariculture industry should be included. It was decided to include chemicals used in finfish, molluscan and crustacean culture, although finfish culture in ICES countries probably employs more chemicals in terms of both quantity and variety than the other industry segments. A second question of scope which was given consideration was whether, since the working group is examining the environmental effects of mariculture, the report should be confined solely to chemicals used in the sea. In some cases, the culture of marine species necessarily requires activity in freshwater; for example, salmon cultivation requires hatcheries and smolt units in freshwater. Development of the mariculture industry will therefore be accompanied by an increased loading of chemotherapeutants to freshwater systems. Equally, whereas the majority of rainbow trout are grown completely in freshwater, a proportion are transferred to sea cages. Thus differentiating between a freshwater species and a saltwater species is not always a simple matter. In addition, many chemicals which are predominantly used in freshwater, find occasional application in mariculture. It was noted also that some freshwater aquaculture operations discharge effluent directly to the sea, and that a proportion of the freshwater culture chemicals discharged into rivers enter the marine environment via estuaries. In order to resolve such complications, it was agreed to include chemicals used in either fresh or saltwater culture, but to devote the majority of the report only to those of primarily mariculture applications.

The technical report on chemical usage will be divided into three principal sections. Section 1 will be comprised of introductory material on the use of chemicals in aquaculture and the reasons for environmental concern. Section 2 will include a discussion of administrative and record-keeping procedures for chemical usage in a few representative member states. The section will also include a list of aquaculture or mariculture chemicals used by ICES member states, identifying in which states each of the chemicals are employed. A preliminary version of this list is shown in Table 2. In the April 1988 report of the Working Group (ICES C.M. 1988/F:32) a list was provided which included all chemicals of use in aquaculture, without distinction based upon frequency of use, countries in which they were used, or industry segment (e.g. finfish or shellfish culture). In order to avoid potential confusion the list of chemicals to be given further consideration by the Working Group has been considerably shortened to include only those used in ICES member states and on the basis of the considerations discussed in the previous paragraph. The preliminary nature of Table 2 cannot be over-emphasized and care is recommended in its use. It represents the most complete information available to the delegates during the working group meeting, but will be altered during the intersessional period. It includes chemicals for which the total quantity used is trivial, and also includes chemicals which are known to be used in culture but could not be assigned to any particular member state. The table will also eventually distinguish between chemicals used in marine and freshwater culture. It is presented as an illustration of the direction being pursued by the Working Group; it is incomplete and in some cases may not be completely accurate.

Section 3 of the technical report will present a list of the quantities of chemicals used in salt water by each country, expressed as a absolute tonnage, and also as a weight of chemical per tonne of fish produced. An preliminary example of the data presentation is shown in Table 3. As will be seen from this table the quantitative data available are extremely sparse and of variable quality. Only seven countries have been able to supply any quantitative figures, and some have only supplied information on antibiotics whereas others have included a full range from therapeutics, disinfectants, anaesthetics, etc. The quantities given in Table 3 are confined to those used in mariculture and do not include the freshwater stages of production e.g. smolt production.

The amounts in use were calculated from a variety of sources either by contact with fish farming organisations or more often from principal chemical suppliers. In the latter case the figures given are sales and may overstate actual usage. Finland has provided data from 1987 and Scotland projected usage in 1989. Figures of usage per tonne production must be treated as provisional, and are

Table 2: Chemicals used in aquaculture or mariculture within ICES member countries. Footnotes: (a) = experimental use only; (b) = approved for non-food fish use only; B = specifically banned

PRELIMINARY DATA ONLY - SEE TEXT FOR CAUTIONARY NOTES

Therapeutic chemicals

	Canada	Denmark	England Wales	Finland	France	Ireland	Netherlands	Norway	Portugal	Scotland	Spain	Sweden	U.S.
Acetic acid	+												+
Acriflavine				+									
Albucid, sodium salt													
Amoxycillin										+			
Ampicillin													
Benzalkonium chloride			+	+						+	+		
Carbasone											+		
Centamicin													
Chloramine T or B	+	+	+	+	+	+	+			+			
Chloramphenicol	B	B				B	+		no data available			no data available	
Chlortetracycline	+												
Clindamycin													
Copper sulfate	+	+	+		+		+			+	+		
Crystal violet													
Cycloserine													
Dibuthyl phthalate	+		+			+		+		+	+		
Dichlorvos	+		+			+		+		+	+		
Dimetridazole		+			+								
Di-n-butyl-tin oxide													
Diquat													+
Doxycycline (tetracycline derivate)													
Enhepten							+						
Erythromycin	+		+					+					
Ethionamide													
Fenbendazole							+	+					
Flumequine						+	+	+					
Formaldehyde (formalin)	+	+		+	+	+	+	+		+	+		+
Fosfomicina													

Table 2: (continued)

Therapeutic chemicals

	Canada	Denmark	England Wales	Finland	France	Ireland	Netherlands	Norway	Portugal	Scotland	Spain	Sweden	U.S.
Furaltadone							+						
Furanace (Nifurpyrinol, Furpyridinol)													+(b)
Furazolidone		+			+		+	+		+			
Gentamicin													
Globucid													
Halquinol													
Hypochlorites				+							+		
Iodophores	+	+	+	+		+	+		no data available	+		no data available	+
Isoniazid													
Ivermectin						+ (c)							
Kanamycin											+		
Kitasamycin													
Levamizol								+					
Malachite green	+	+	+	+	+	+	+	+		+	+		
Mebendazole		+					+						
Methylene blue				+ (a)									
Metronidazole													
Minocycline													
Nalidixic acid											+		
Natamycin								+					
Neomycin							+						
Nifurprazine hydrochloride													
Nitrofurantoin													
Nitrofurans											+		
Nitrofurazone							+						
Olaquindox							+						
Ovadine													
Oxolinic acid	+	+	+		+	+		+		+	+		
Oxytetracycline	+	+	+	+	+	+	+	+		+	+	+	+
Penicillin	+												
Phenoxethol													

Table 2: (continued)

Therapeutic chemicals

	Canada	Denmark	England Wales	Finland	France	Ireland	Netherlands	Norway	Portugal	Scotland	Spain	Sweden	U.S.
Potassium permanganate	+	+	+		+		+				+		+
Prazinquantel								+					
Prefuran	+												
Quaternary ammonium compounds										+			
Rifampicin													
Roccal													
Romet 30 (Sulfadimethaxine and Orthomeprim)	+								no data available			no data available	+
Ronidazole							+						
Sodium chloride	+	+	+	+			+	+		+			+
Sodium nifurstyrenate													
Spiramycin													
Streptomycin								+			+		
Sulfisoxazole													
Sulfonamides							+						
Sulfamerizine	+						+						+
Sulphamethazine		+									+		
Tetracycline													
Tiamulin													
Tribrissen (Sulphadiazine and Trimethroprim)	+	+	+		+	+	+	+		+			
Trichlorfon			+		+			+			+		+ (b)
Trifluralin													

Disinfectants

	Canada	Denmark	England Wales	Finland	France	Ireland	Netherlands	Norway	Portugal	Scotland	Spain	Sweden	U.S.
Chlorine; Sodium or Calcium hypochlorite	+			+			+		no data available		no data available	no data available	+
Formaldehyd (Formalin)		+		+			+						
Hypobromide					+								
Iodophors	+	+		+						+			+
Quaternary ammonium compounds				+									+(b)

Anaesthetics

	Canada	Denmark	England Wales	Finland	France	Ireland	Netherlands	Norway	Portugal	Scotland	Spain	Sweden	U.S.
Benzocaine				+	no data available		+		no data available	+	no data available	no data available	
Carbon dioxide		+		+						+			+
Chlorbutanol		+											
Metomodate	+												
MS 222	+			+		+							+
Phenoxy-ethanol	+												
Sodium bicarbonate													+
Tert-amyl alcohol	+												

Piscicides

	Canada	Denmark	England Wales	Finland	France	Ireland	Netherlands	Norway	Portugal	Scotland	Spain	Sweden	U.S.
Antimycin					no data available				no data available		no data available	no data available	+(b)
Rotenone				+				+		+			+(b)
Tea seed cake													

Hormones

	Canada	Denmark	England Wales	Finland	France	Ireland	Netherlands	Norway	Portugal	Scotland	Spain	Sweden	U.S.
Carp gonadotropin				+ (a)	no data available		+		no data available		no data available	no data available	
Estradiol													
Human Chorionic Gonadotropin				+ (a)			+						
Luteinizing-release hormone													
Mare serum gonadotropin							+						
Methyltestosterone	+			+		+ (a)				+			
Progesterone							+						
Pituitary extract				+ (a)						+			

Herbicides/Algicides

	Canada	Denmark	England Wales	Finland	France	Ireland	Netherlands	Norway	Portugal	Scotland	Spain	Sweden	U.S.
Acid blue and acid yellow													+(b)
Aluminium sulfate					no data available				no data available		no data available	no data available	+
Amitrole													+(b)
Copper, elemental				+									+
Copper sulfate	+	+		+									+
Dichlone													+(b)
Dichlorbenil													+(b)
Diquat dibromide													+
Endothall													+
Glyphosate													+
Potassium ricinoleate													+
Simazine													+
Xylene													+
2,4-D													+

Antifoulants

	Canada	Denmark	England Wales	Finland	France	Ireland	Netherlands	Norway	Portugal	Scotland	Spain	Sweden	U.S.
Copper oxide				+	no data available				no data available	+	no data available	no data available	+
Tributyltin	B		B		no data available	B			no data available	B	no data available	no data available	

Dyes

	Canada	Denmark	England Wales	Finland	France	Ireland	Netherlands	Norway	Portugal	Scotland	Spain	Sweden	U.S.
Fluorescein sodium					no data available				no data available		no data available	no data available	+
Malachite green				+	no data available	+			no data available	+	no data available	no data available	
Rhodamine B and WT					no data available				no data available	+	no data available	no data available	+

Non-nutritive feed additives

	Canada	Denmark	England Wales	Finland	France	Ireland	Netherlands	Norway	Portugal	Scotland	Spain	Sweden	U.S.
Astaxanthin				+	no data available				no data available	+	no data available	no data available	
Canthaxanthin	+			+	no data available	+			no data available	+	no data available	no data available	
Ethoxyquin				+	no data available		+		no data available	+	no data available	no data available	

other chemicals

	Canada	Denmark	England Wales	Finland	France	Ireland	Netherlands	Norway	Portugal	Scotland	Spain	Sweden	U.S.
Calcium hydroxide, oxide, carbonate				+	no data available				no data available		no data available	no data available	+
Carbaryl					no data available				no data available		no data available	no data available	+
Cytochalasins					no data available				no data available	+	no data available	no data available	+

Table 3: Quantities of chemicals used in mariculture within several ICES countries. Quantities are given as kg and, in parentheses, kg per metric ton production. All estimates are based on 1988 usage with the exception of Finland (1987) and Scotland (projected 1989).

	Canada a)	Denmark (b)	England Wales	Finland	France	Ireland	Netherlands	Norway	Portugal	Scotland	Spain	Sweden	U.S.
17-alpha Methyl-testosterone										$1x10^{-4}$ ($3x10^{-6}$)			
Actomar B 100 (Quaternary ammonium compond)						430 (0.6)							
Actomar K 30 (Iodophor)						365 (0.5)							
Amoxycillin										500 (0.014)			
Astaxanthin										1500-2000 (0.04-0.06)			
Benzocane			No data available		No data available		No data available		No data available		No data available	No data available	No data available
Calcium carbonate				650 (0.1)									
Canthaxanthin						180 (0.04)				1500-2000 (0.04-0.06)			
Chloramine B						87 (0.015)							
Chloramine T						18 (0.003)				1500-2000 (0.04-0.06)			
Clodin (phosphoric acid)						141 (0.024)							
Copper oxide										small			
Dibutyl phthalate						1553 (0.26)				20,000-30,000 (0.6-0.8)			
Dichlorvos						1553 (0.26)				20-30,000 (0.6-0.8)			

[a] Canadian west coast only   [b] based on provisional data available to the Working Group and should be considered tentative

Table 3: (continued)

	Canada a)	Denmark b)	England Wales	Finland	France	Ireland	Netherlands	Norway	Portugal	Scotland	Spain	Sweden	U.S.
Erythromycin										4000-5000 (0.11-0.14)			
Formaldehyde						small				small			
Furazolidone										500-1000 (0.014-0.03)			
Iodophors			No data available		No data available		No data available		No data available	small	No data available		No data available
Malachite green						Trace				small			
MS 222						1,0 (0.00002)							
Oxolinic acid		2,560 (0.6)				29 (0.006)				10,000-15,000 (0.3-0.4)			
Oxytetracycline	2,880 (0.48)					362 (0.08)				10,000-15,000 (0.3-0.4)		414 (0.69)	
Rhodamine B										small			
Romet 30	320 (0.053)												
Sulfamerazine		5.2 (0.001)											
Tribrissen						410 (0.085)				8000 (0.23)			

[a] Canadian west coast only [b] based on provisional data available to the Working Group and should be considered tentative

based on reported production for each country. Quantities shown are based on the active ingredient. In the case of dichlorvos, for example, the industry reports usage as total kg of Nuvan sold but the amounts in the table are calculated as the active ingredient of 50% dichlorvos. The quantities are valid only for the year shown and may exhibit considerable annual variation. For example, in Ireland the main drug in use for furunculosis treatment was oxolinic acid up to 1987 but resistance problems caused a shift in usage to oxytetracycline in 1988.

Absolute amounts of each chemical by country are given but are also broken down into amounts used per tonne of fish produced to avoid distortion. Norway, with a production of almost 90,000 tonnes of finfish in 1988, used a total of 18,220 kg of oxytetracycline or 0.21 kg/tonne of fish produced. Whereas British Columbia with a production of 5,800 tonnes used 2,880 kg or 0.48 kg/tonne of fish - over twice the Norwegian dose. (This example is used merely by way of a chemical-specific illustration and does not reflect the usage of total antibiotic per tonne of fish produced). In Finland overall production has increased dramatically in the last ten years but antibiotic usage per tonne of fish produced has decreased to 0.115 kg/tonne.

It is intended that both Tables 2 and 3 are provisional and that members of the Working Group will further examine and update the data presented for the final technical report.

Section 4 will include data sheets on mariculture chemicals cited in Section 2. An example of the data sheet format is provided in Figure 2. For many chemicals, and particularly those which are used in small quantities (e.g. methyltestosterone) or are unlikely to have significant environmental consequences (e.g. carbon dioxide), the data sheet may be limited to synonyms, purpose and mode of treatment). For chemicals in widespread use and of potential environmental significance (e.g. antibiotics, dichlorvos) much additional environmental information will be provided on persistence, fate, toxicity, etc. Such information is not presently available in a consolidated format, and consequently the data sheets should prove very valuable.

Wild and cultured fish interaction

In several countries concern has been expressed on the consequences of locating fish farms near major spawning streams. Norway generally excludes new salmon farming from areas of natural salmon runs at varying distances (up to 20 km). In British Columbia, a minimum distance of 1 km of a farm from the river mouth is necessary for those rivers known to have a salmon run. All of these distances are arbitrarily determined and are not based on scientific data.

The Working Group has been requested by NASCO to comment on the potential effects of escaped cultured fish (Atlantic salmon) on native salmon populations. The Working Group felt at the present time unable to provide advice on the subject; it did, however, discuss the request relative to habitat and disease aspects.

Habitat interactions

Working Group members did not have any information on possible effects of culture structures (cages) on the general behaviour of wild salmon. No information is available on the possible effects of pheromone release by cultured fish on wild salmon populations. Research in this areas has not yet been initiated.

Unofficial information available to the Group suggests that studies are in progress in Norway to determine how escapees from farms might contribute to spawning populations. It is hoped that the results of the research work presently going on in Norway will be available at the next Working Group meeting.

Several studies have reported higher densitites of wild fish in close proximity to finfish cages than in reference areas. Work in Scottish freshwater lochs has shown that the introduction of rainbow trout culture has increased the growth rate of native roach *(Rutilus rutilus)*, brown trout *(Salmo trutta)* and stocked rainbow trout (Forbes, 1981; Phillips et al., 1985). The culture site is likely to represent an area of enhanced food availability.

In other locations such as British Columbia, Canada juvenile wild fish particularly herring and wild salmon are found to enter cages used to culture the piscivorous coho and chinook salmon. There is thus, concern that the caged salmon may be feeding on wild stocks particularly if these are attracted to the cage culture operation. There is presently study underway to examine to what extend such predation may occur.

The Working Group also referred to the work done in France on the possible behavioural and habitat interactions of introduced Pacific salmon (coho) on Atlantic salmon. The results of the French studies have been reported in the documents of the ICES Working Group on Transfers and Introductions of Non-indigenous Species and at Statutory Meetings of ICES and it is suggested that NASCO discuss this subject further with the latter Working Group.

Disease Considerations

There have been many expressions of concern about perceived dangers arising from the release of pathogenic microbes and parasites from mariculture sites. The perceived danger is to wild species and to other mariculture sites.

Where the pathogen will be an introduction i.e. not a native of the region or country, then it is probable that such perceptions of danger to wild or farmed stocks are real. It should be an objective of national regulatory agencies to prevent the introduction of such pathogens through national laws (see e.g. ICES/EIFAC Code of Practice to control introductions of non-indigenous species). Where endemic pathogens cause disease as a consequence of density dependent stress factors in mariculture sites then they will not pose a **new** threat to wild populations.

Pathogens may be endemic but not necessarily so abundant or infectious that stocks on a mariculture site will contract the pathogen in any season. Over many seasons of operation the risk of contraction will be higher. Where some (or one) mariculture sites in a region or area have such a disease then the possible spread of the pathogen between sites will depend on many unquantifiable factors. A broad generalisation of the position might be that sites sharing the same waters and wild or escaped fish will sooner or later share the same diseases.

Where an introduced species is being cultured its interaction with endemic pathogens is uncertain. The possibility for change in the pathogen is real but the ecological significance is uncertain. Change in endemic pathogens in native species in mariculture is also possible e.g. antibiotic resistance but again the ecological significance and any significance for human health is uncertain.

The main concerns on interactions between wild and farmed salmonids relate to the genetic threat and to disease transmission. The Working Group suggests that NASCO should discuss these subjects with the following additional ICES Working Groups: (Working Group on Transfers and Introductions of Non-indigenous Species; Working Group on Genetics; Working Group on Pathology and Diseases of Marine Organisms).

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Research priorities.

The Working Group recommends research on the following areas:

- The development and evaluation of techniques for the measurement of environmental parameters used in site evaluation and monitoring of the environmental impact of mariculture
- Formulation and verification of models for predicting carrying and holding capacity.
- Environmental impact of mariculture and ecotoxicological studies on new chemicals in mariculture. Quantities of chemicals currently used in mariculture.
- The development and significance (if any) of antibiotic resistant strains in the biota.
- Assessment of the interaction between wild and cultured species.

Recommendations

(1) The Working Group recommends that it meet from March 27 to 30 in Aberdeen to undertake the following tasks:

(a) review ongoing research and monitoring programmes on environmental issues related to mariculture, to compare results from various countries, to facilitate transfer of information and identify research priorities.

(b) to continue work on a draft technical report on "Management of the environmental impact of mariculture," which could be considered for publication by the mariculture committee.

(c) to complete the draft document on "Chemicals used in Mariculture", and especially to complete the "information sheets" on chemicals so that the final manuscript can be considered for publication by the parent committee at the 1990 Statutory meeting of ICES

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(not included in any of the previous Working Group Reports)

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Working Group on Envirnmental Impact of Mariculture

April 19 to 24, 1989

Dunnstaffnage Marine Laboratory, Oban, Scotland

Agenda

(1) **Opening of the Meeting**

(2) **Election of Rapporteur(s)**

(3) **Overview on recent ICES Activities and report on the status of past WG Recommendations**

(4) **Tabling of Documents**

(5) **Adoption of the Agenda**
(assignemts to and timing of drafting sessions)

(6) **Presentation of the Remots System** (by invitation)

(7) **Country Reports**
- Production trends
- Reports on ongoing research programmes
- Research priorities

(8) **Site selection criteria**
- -Large-scale zoning (mapping) (LENKA-project, other programmes)
- -Remote Sensing (US programmes and others)
- -evaluation procedures for specific sites

(9) **Environmental monitoring, including monitoring and the determination of carrying /holding capacity**
- -for evaluation of site suitability
- -for onsite environmental control (the view of the farmer)
- -for environmental protection (the view of control agencies)
- -essential parameters to monitor
- -monitoring strategies (when,where,how; reporting system)
- -specific techniques (REMOTS-system and others: evaluation of the presentation given under item (6)

(9) **Chemicals used in aquaculture**
- -listing of relevant chemicals commonly used
- -discussion on chemicals less frequently used
- -listing of quantities used in various countries
- -discussion on quantities used in various farming types
- -descriptive material and quantifying information on the effects of chemicals (mode of chemical reaction, toxicity, ecological effects, concern on resistance, etc.)

(10) **Recent relevant literature**

(11) **Conclusions and recommendations**

(12) **Miscellaneous**

Appendix 3

ICES Working Group on "Environmental Impact of Mariculture
Oban 19-24 April 1989

Country Reports

Country Report Denmark

by Jesper Hørsted

Production

The gross production of rainbow trout *(Salmo gairdneri)* in Danish mariculture in 1988 was about 5,500 tonnes (net production 4,400 tonnes) of which 91 % was raised in cage farms. The production of turbot *(Scophtalmus maximus)* and salmon *(Salmo salar)* was 2 tonnes and 1 tonnes, respectively. The total food consumption was about 6,600 tonnes giving a food conservation coefficient of 1.5. The number of cage farms and land-based farms was 27 and 10, respectively. The production of mussels *(Mytilus edulis)* and oysters *(Crassostrea gigas)* was 400 tonnes and 1.5 tonnes, respectively.

The maricultue production is limited by the environmental authorities and there is still a moratorium on new farms. New permits will not be granted before the national plan for mariculture development from the Ministry of the Environment is published (some time in the near future).

Use of chemicals

A list of chemicals used in Danish mariculture is enclosed (carried out by Inger Dalsgaard).

The total use of chemicals in Dabish mariculture in 1988 was 1024 kg Oxolinic acid and 2.1 kg Sulfonamerazine. These figures are based on informations from about 40% of the total production. Oxolinic acid are commonly used for 7 days in concentrations of 12 mg x kg fish $^{-1}$ x day $^{-1}$.

Research

Calculations concerning the collected material and data from 1988 are not finalized but up to now following conclusions are made based on research at three cage farms and one land-based farm:

There are no measureable effeect from cage farms on inorganic nutrients and pH.

Phytoplankton biomass are only slightly increased at one location in some parts of the year.

The particle volume of particles larger than 15 µm are reduced up to 50% by passage of one cage farm while smaller particles only are moderately influenced.

Only slightly decreased oxygen tension are found around cage farms in the warmest part of the year.

The primary production are nitrogen limitated during most of the fish production season in Danish mariculture.

Growth of phytobenthos are slightlly increased near cage farms but species composition are not changed.

Dry matter, loss by ignition and the total nitrogen content of the sediment underneath cage farms are nearly unaffected compared to reference stations, while total phosphorous content are higher near the cage farms.

The zoobenthos biomass underneath cage farms are nearly unaffected while the species composition are slightly affected compared to reference stations (i.e. lower Shannon-index).

Biomass of wild fish populations are about 3 times higher underneath cage farms while mean size and species composition are unaffected compared to reference stations.

The crab and hermit crab population near the cage farms are unaffected by the cage farms.

There was not found any antibiotics residues in the wild fish population around the farms.

Filtration effeciency of total nitrogen and total phosphorous in a land-based fish farm was calculated to 43% and 57%, respectively. For nitrogen this is higher than "theoretical possible" caused by filtration of particles from the influent water through the 80 µm filters. The calculations are based on differences in concentration between influent and effluent water and knowledge about food ration and food conversion coefficient.

Data and computations concerning bacteria compostion and bacterial resistance to medicine are not finalized.

The reseach in 1989 will be continiation of the 1988-programme. Furthermore laboratory experiments using large rainbow trout are started. In these experiments nitrogen, phosphorous and organic matter of the fish and the waste water are measured in relation to type of food, temperature, fish size and fish quality.

Chemicals used in fish farming in Denmark

1) Chemicals specially authorized: Tricofuron (nifurazolidonum), Tribrissen (sulfadiazinum: Trimethoprimum, 5:1)

2) Chemicals commonly used in aquacultre: 3) + 4). Anaesthetics: carbondioxid, chlorbutanol

3) Chemicals sold with veterinarian prescription only: Sulfamerazine, Trimethoprim, Oxolinic acid, Oxytetracyclin, Emtryl (dimetridazolum)

4) Chemicals used and sold freely: Vermox (mebendazolum) Salt, Formalin, Malachite green, Chloramine T, Iodophor, Copper sulphate, Potassium permanganate

5) Control of rest-concentrations in fish before sale: Regulation No 199 of March 22th, 1988 for prevention of drug residues in fish for human consumtion. The Veterinary Department can stipulate the withdrawl time, but it is not done yet. - No control -

6) Chemicals banned: Chloramphenicol

Until now only chemotherapeutics have been used in mariculture, all the chemicals mentioned are used in freshwater farms.

Country Report Finland

by Timo Mäkinen
Finnish Game and Fisheries Research Division
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1. Production figures

Expansion of fish farming has occurred rapidly during the last decade in Finland. The total number of farms has almost tripled over 10 years period. During the last years the increase of the number of net-cage farms has been most rapid (Figure 1). The majority of these net-cage farms are located in the brackish water area along the coast line.

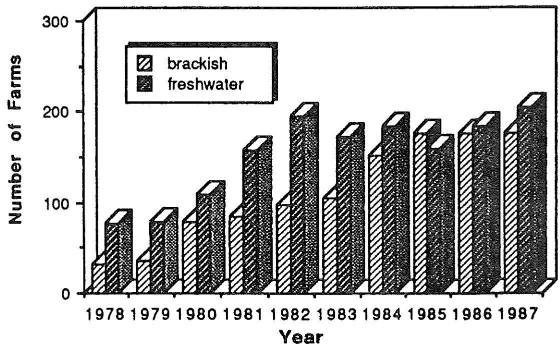


FIGURE 1. Number of fish farms in Finland

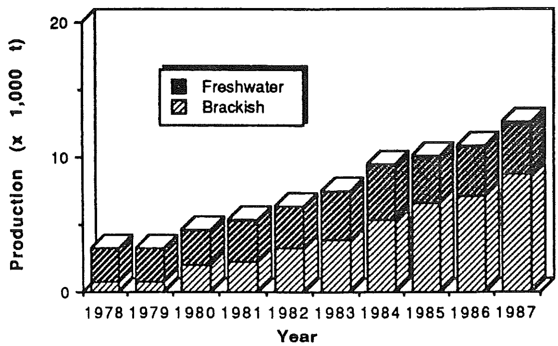


FIGURE 2. Food fish production in Finland *(to be inserted)*

The total food fish production in Finland in 1987 was over 2,000 tonnes (Figure 2) with large rainbow trout as the main product (99 %). Only some hundred tonnes of salmon were produced.

In 1982 production in brackish and fresh water was equal. However in 1987 only one third of all fish were produced in fresh water. The share of production capacity of fresh water net-cage farms is at present less than fifteen per cent of the total area of net cages.

2. General Legislation and Monitoring Practice

According to water regulations practically all fish farms in Finland must have a licence issued by the Water Court. This licence specifies the maximum allowable capacity as well as the amount of feed to be used, the maximum allowable growth rate and biomass of the fish.

The farmer is obliged to keep a diary for inspection by the authorities; all data concerning the use of water, feed, medication and other parameters specified in the licence must be recorded. Farmers are also obliged to pay for control studies on their effluent quality and investigations of the environmental impacts on the recipients of the effluents.

For land-based farms the sampling to document effluent water quality is done by collecting samples at least over 48 hours and this must be done 3-12 times annually depending on the size of the farm.

The environmental impact on the recipient may be studied 3-6 times per season by measuring total phosphorus and chlorophyll content in the trophogenic layer of the recipient-lake. Temperature, secchi-disc depth and (in the sea area) also the conductivity is determined. The biggest farms and the brackish water net-cage farms may be obliged to include in the studies fishery-, benthos- and sediments surveys, as well.

The costs of the effluent and recipient monitoring studies have been on the average at the level of 0.4 - 0.11 US $ per kilogram fish produced. In the marine area where only recipient monitoring is done the costs have been about 0.02 - 0.07 US $ per kilogram fish produced (Häkkilä 1988).

The Finnish National Board of Waters and Environment represents common interests in the Water Courts. It is also the authority accepting the monitoring programmes from fish farms. The attitude of the National Board of Waters and Environment is thus very decisive regarding the extent of fish farming.

For monitoring of net-cage farms the same programmes, used for freshwater land based farms have been applied. The data for nutrient and chlorophyll concentrations have nevertheless only occasionally shown any detectable change in the marine environments. The biggest farms are therefore, obliged to include in the studies fishery-, benthos-, and sediments surveys as well.

The transfer, by the authorities, of the basic concepts from the freshwater areas to the brackish water has been a misconception, since there is a lack of scientific understanding of the holding capacity of the coastal areas (e.g. such as the Vollenweider model for limnic areas).

The net-cage farms have been seen as one case where industrial activities and the water protection measures demanded by the authorities has been the same. Because the net cage farms do not have any effluent pipes to which effluent treatment facilities could be attached some of the farmers are obliged to pay "water protection charges" in the same way as other industrial operations; They do not, however, have any capacities to purify their effluents.

Instead of viewing them as industrial operations and thus a point source of effluents it would be better to consider marine fish farms as (aqua)culture installations and oblige them to take care of their own environment through appropriate site selection and monitoring programmes. The monitoring programmes should be designed specifically for marine areas and not simply as application of fresh water monitoring protocols.

3. Future Trends of Production and Development

The Finnish Foundation for Development Areas assessed the potential for the development in fish farming in Finland and provided the following evaluation (Hakanen et al. 1987):

The food fish production is expected to double in the early 1990's. Rainbow trout will again be the major species farmed, but also farming of other fish species will gain importance. The main market will be the domestic one. Production of young fish is not expected to limit the food fish production in the future. On the contrary, there may be occasional overproduction of smolts.

In the same study the authors could not anticipate any great increase in the production from stocking natural waters, but changes may occur in the relative numbers of fish stocked in Finland.

The finnish fish farming industry employs about two thousand persons directly (Partanen et al. 1988). Indirect employment effects are estimated to be several times the above figures contributing to the economic growth of the society. Fish farming is seen as an area which still has some room for expansion and which may employ more people in the remote areas of Finland.

Fish farming in Finland is now a common and well estblished trade. Out of the fish food production, about 99 % consists of large-sized, i.e. over 800 g rainbow trout. The sales value of the production was about 70 million US $ in 1987 (Figure 3).

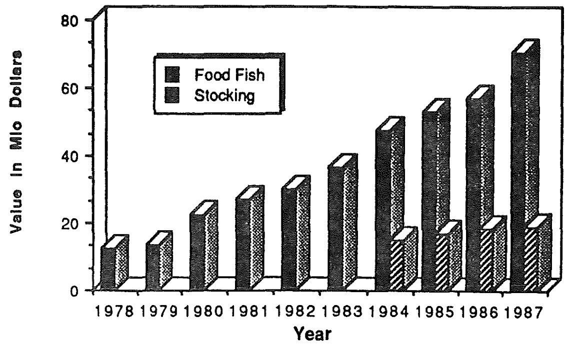


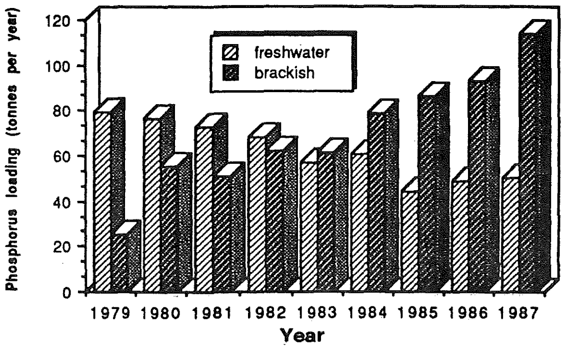
Figure 3. The value of farmed fish production in Finland

As a general trend in the finnish fish farming there is now a relative increase in food fish production in marine areas, while the production of fingerlings is becoming more prominent in freshwater farming.

4. Loading from Fish Farming

The production of fish to stocking size in Finland is now estimated to be about 600 tonnes annually. This means that an estimated amount of about 7 tonnes of phosphorus and about 45 tonnes of nitrogen loading is derived from this culture.

The nutrient loading from food fish farming is estimated to be about 140 tonnes of phosphorus and 950 tonnes of nitrogen annualy. The contribution of fresh water and marine farming to this overall nutrient load is presented in Figure 4 (Mäkinen 1988).



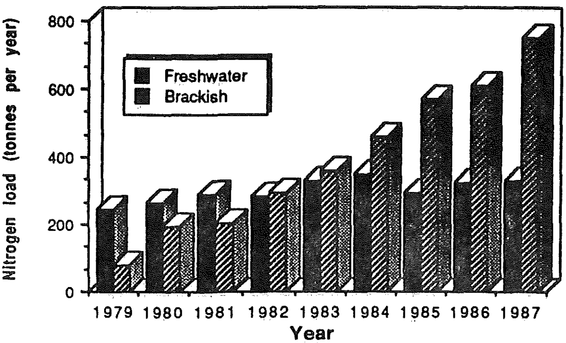


Figure 4. Estimated phosphorus (Upper figure) and nitrogen load (lower figure)

The contribution of the nutrient load from the fish farms to the total nutrient load derived from human activities is small in Finnish waters: under four percent for phosphorus and under two percent for nitrogen (KOMITEANMIETINTÖ 1986).

4.2. Environmental loading through other substances: Chemicals and antifouling agents

The following quantities of various substances were compiled from data colected by the National Veterinary Administration and by the National Board of Waters and Environment in Finland. Overlap of data and missing data were corrected as far as possible. However, the data presented here contain still some inconsistencies and describe only the scale of the consumption of medication and other chemicals in finnish fish farming.

In marine areas the use of chemicals than antifouling agents and antibiotics is negligible. Oxytetracycline is the mainly used antibiotic in brackish water net cage farms with a total amount of about 1050 kg annually.

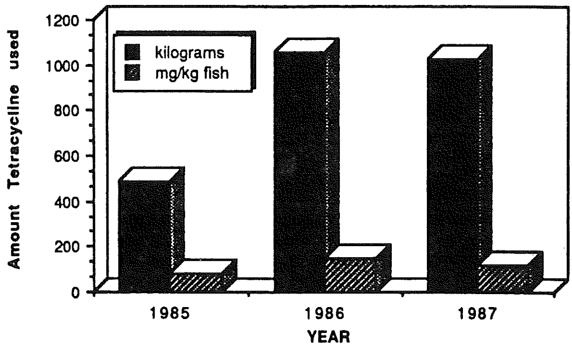


Figure 5: The use of antibiotics (tetracycline) in marin net-cage farms in Finland

5. New Studies on Environmental Impact of Fish Farming in Finland

Testing of a new innovative techniques for sludge collection from earthen ponds is presently in progress in Finland (Karttunen et al. 1988). A prototype of a specially deviced unit, consisting of floating "whalebones" on the bottom for trapping and collecting of drifting sludge was tested. The aim of the study is to develop an economically feasable way to remove suspended solids and settled sludge from old fish farms employing very long earthen ponds.

In 1987 the Nordic Council of Ministries agreed to fund a three years project with the aim to develop an environmental impact assessment strategy for marine fish farms. This project will serve as a model to be utilized for planning purposes and for a better exploitation of coastal areas.

Besides internal measures (improved management) to reduce the pollutional load from net-cage farms the selection of an appropriate site for placing of a farm is one of the most important ways to minimize harmful environmental effects.

The preliminary report of this project on "Basic Concepts Concerning Assessments of Environmental Effects of Marine Fish Farms" is already published (Håkansson et al. 1988).

The residues and the persistence of oxytetracycline was studied in wild fish and sediments in 1987 in the finnish archipelago (Björklund et al. 1989). In wild fish residues of oxytetracycline were detected up to 13 days after medication. The half-life of oxytetracycline in fish farm sediments were 9 days on other and 419 days on other farm.

The clearance time for chemotherapeutants such as oxytetracycline is 30 days in Finland and this time limit applies for the summer time. During winter this time is longer and lasts up to the 60 days. The exact time is determined for each operation by the veterinarians.

Country Report Ireland

Jaequeline Doyle
Fisheries Research Centre
Dublin

1. Production Trends

Farming of salmonids is projected to reach 14,000 tonnes by 1992. However, pancreas disease furunculosis and Sea lice infestations remain the most important diseases necessitating the use of antibiotics or chemicals for treatment.

Production of rope culture of mussels is also expanding. However, protracted closures in the South West to due to infestation with Diarrhetic shellfish poisining (DSP) toxin caused some loss of production in 1987.

Production trends (tonnes)		1986	1987	1988
Atlantic salmon		1215	2 232	4 000
Rainbow trout	- marine	63	320	500
	- freshwater	470	600	680
Mussels - *Mytilus edulis*				
	- rope	1636	1 500	N/A
	- extensive	9248	11 870	N/A
Oysters	*Ostrea edulis*	100	160	N/A
	C. gigas	120	104	N/A

N/A - not yet available

Mandatory monitoring programmes, as required by an Aquaculture Licence, are continuing as outlined in ICES doc. C.M. 1988/F:32. Considerable data banks are being assembled for each site and are currently being assessed and reviewed to establish the need for and frequency of sampling at each site for protracted periods. Where steady state production targets have been achieved and no unacceptable deterioration of the surrounding environment identified, modifications of the programme may be introduced.

2. Research priorities

(1)Replacement of Dichlorvos (Nuvan) with alternative therapies.

(2)Effects of Dichlorvos on crustaceans and molluscs

(3)Reduction of antibiotic inputs

(4)Chemical Methods for detection of Dichlorvos

(5)The use of alternatice techniques for monitoring environmental impacts of aquaculture

(6)Environmental impacts of fin-fish and shell-fish culure on embayment-systems.

3. Preliminary results

3.1 The use of Dichlorvos (Nuvan) continues to give cause for concern, both for its possible neurotoxic effects on farm operations and on the life cycles of commercially important species.

An alternative drug (as a lice therapy) Ivermectin has been tested experimentally under field conditions. The drug is orally administered. At treatment levels tested the numbers of lice present and associated lesions were significantly lower than those of control fish.

On removal of the drug from the feed, lice numbers remained low for approximately 30 days. No adverse effects were detected in treated fish. Attempts to detect residues in tissues of treated fish using a chemical method with a detection limit of 0.1 ppm failed. Human toxicological studies are now being considered.

Contact: Dr Peter Smith, Department of Microbiology, University College Galway (U.C.G.).

3.2 The Effects of Dichlorvos (Nuvan) on Crustaceans and Molluscs

A number of studies have been undertaken to establish the sublethal effects of Dichlorvos.

3.2.1 At the Fisheries Research Centre (C.B. Duggan, 1989, in press) laboratory experiments were conducted which showed that for crustacean species tested mortality was both rapid and high at the recommended Nuvan working strength for salmon cages, i.e. 1 part Nuvan per million. At diluted strengths of 10^{-8} test crustaceans died within two to three days. Tests with molluscs especially the limpet *Patella vulgata* and *Gibbula lineata* (Monodonta) showed that at concentrations of 10^{-10} changes in behaviour occurred, in that the limpet lost its protective ability to clamp firmly. Test molluscs recovered when placed in clean water. The force required to dislodge *Patella* from a substrate was significantly lowered by Nuvan at concentrations of 10^{-10} often less than 21 hours at temperatures of 19°C. It is not yet known whether the observed experimental effects have been matched by corresponding environmental effects in the wild. This is a possible bio-test for the presence and persistence of low concentrations of Dichlorvos in farm areas.

3.2.2 At the Regional Technical College (RTC) Galway (Dr B. Ottway) studies showed that Dichlorvos was toxic to *Palaemonetes varians* (a small brackish water "shrimp") at concentrations of 10^{-8}.

3.2.3 Also at RTC Galway studies are being directed towards developing a sensitive chemical method for the detection of very low levels of Dichlorvos in seawater.

3.2.4 The use of liposomes to package antbiotics to render them insoluble and unavailable in the marine environment is being examined, as is the development of antibiotc resistance at the Dept. of Microbiology University College Galway (Dr. P. Smith).

3.2.5 At the same Department the feasability of using competitive exclusion to control pathogens on the surface of fish is being examined. Results suggest that there is competitions between bacteria sp. and between bacteria and fungi for niches on the surface of wild fish which are able to reduce the numbers of *Aeromonas salmonicida* and *Saprolegnia* from the surface of fish. In laboratory experiments, the technique has reduced the frequency of latent furunculosis in salmon from 75% to 10% and has shown promise in controlling a clinical out break of the disease. Development of drug free therapies may reduce on eliminate the use of chemicals.

3.2.6 Comparisons were undertaken to evaluate the use of Divosan Forte abd Divosan Hypochlorite as sterilizing and decolourizing agents for blood water arising from killing at sea Divosan Forte proved most effective in minimizing impacts on sea water and is totally biodegradable (Dr. P. Smith, U.C.G.).

3.2.7 A sediment profile imaging technique REMOTS® (Remote Ecological Monitoring of the Sea floor) was used to study the impact of Mariculture both....fish and shell-fish farming on embayment systems on the West Coast of Ireland (Dr. Brendan Keegan Benthos Section University College, Galway). This technique shows promise as an additional tool for environmental impact assessment.

3.2.8 A detailed study of the Environmental conditions in Kilkieran and Bertraboy Bay with intensive aquaculture activities has been completed. Mercer et al, 1989 in press, Aquaculture Technical Bulletin, 250 pp.).

Country Report The Netherlands

by Renger Dijkema
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Production trends

Mussel *(Mytilus edulis)* cultivation saw its production strongly reduced by heavy storms in the Waddenzee area. Oyster*(Ostrea edulis* and *Crassostrea gigas)* production remained more or less at the same level. The oyster disease *Bonamia ostreae* was in 1988 transferred from the Oosterschelde to Lake Grevelingen, which, after the outbreak in the Oosterschelde in 1980 had remained free of this disease. Bottom cultivation of cockles *(Cerastoderma edule)*, carried out on an experimental scale since 1979, was discontinued. Cultivation of eels in freshwater recirculation systems showed a stabilization in 1988. The only eel farming operation in seawater stopped. Cage culture of rainbow trout in seawater remained limited to one small project.

Aquaculture Production in The Netherlands in 1987/88

Species	Production in tons x 1000	Number of firms
Blue mussel	70.5	79
European flat oyster	1.0	16
Pacific oyster	0.7	14
Cockle	0.2	1
Eel	0.15	8
African catfish	0.4	5 (full-time) 35 (part-time)

Research activities

Fish farming

Research into possibilities for cultivation of turbot in (semi) recirculated systems was started at the Netherlands Institute for Fishery Investigations. The experiments will be extended in 1989.
Eel cultivation research was chiefly aimed at feeding of glass eels and also of eels in the on-growing phase. A comparative research program into different recirculation systems and their functioning was embarked on.

Mollusc cultivation research

Simulation models for the ecosystems of the western Waddenzee (EMOWAD) and the Oosterschelde (SMOES) are respectively being completed and validated. Trial runs indicated that both still need extensive calibration and validation before they can be used for assessment of the carrying capacity for mussel cultivation in both areas.

Research into growth rate, condition index and food supply of cultivated mussels in the Oosterschelde revealed that there is a significant correlation between primary production and growth and condition of mussels in that area. Year-to year changes in growth rate and meat yield (used as condition index) appeared to be related to fluctuations of the primary production rather than to changes in chlorophyll concentration. This indicates that the condition index of mussels could be a useful tool for monitoring changes in primary production due to eutrophication in areas with intensive marine fish farming operations.

After the completion of a flood barrier in the mouth of the Oosterschelde, the pattern of distribution of suspended food seems to be changed, resulting in a reduced growth and condition on a number of mussel cultivation plots. It is supposed that, after the completion of the flood barrier in the mouth of the estuary, the position of many plots in the mouth of the estuary does not longer match the changed pattern of tidal currents and hence of particulate food supply. Attempts will be made to find a more favourable distribution of the cultivation plots over the entire estuary.

Country Report Norway
by

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Institue of Marine Research
Bergen

Production trends

Figures for the total Norwegian Aquaculture production in 1988 is presented in Table 1.

Table 1: Total Norwegian Aquaculture Production in 1988. (Compiled from various sources).

Atlantic Salmon		80 000	tonnes
Rainbow Trout		9 000	"
Arctic Char		8	"
Blue Mussels		93	"
Cod		15	"
Cod fry	(numbers)	500 000	
Turbut fry	(numbers)	260 000	
Halibut fry	(numbers)	1 400	
Oysters	(numbers)	95 000	
Lobster	(numbers)	8 000	

The farming of salmonids has been prosperous, with relatively few health problems and a production constantly above the prognoses. The loss due to the algal bloom in May was less than 0.5% of the total production, this was partly due to the towing of the net cages away from the bloom and into the fjords. In 1989 the production is expected to be about 120 000 tonnes.

The work with fry of marine species continues with a steady increase in numbers produced. A lot of effort will be put into the production of halibut fry, an a substantial increase in numbers is expected in 1989.

Reports on ongoing research programmes

Ongoing research programmes are presented in the appendix.

Research priorities

The *Chrysochromulina* bloom May 1988 in Kattegat and Skagerrak has sharply increased the public interest in marine pollution. The ongoing debate has not terminated and it is not yet clarified what will be the main research priorities. It is, however, clear that the environment impact from mariculture will be a field of high priority. As a result of this a research programme dealing with these items will be initiated.

The lack of knowledge on the ecological impact of chemicals used in mariculture is a matter of concern, and research projects are started. Another area of main interest is possible genetic interactions between farmed fish and river stocks, and a research programme is about to be started. Other fields of priority are holding capacity, eutofication caused by mariculture and the connection between environment and fish health.

United Kingdom

by

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Marine Laboratory Aberdeen
Scotland

and

Richard Gowen
Scottish Marine Biological Association
Oban, Argyll

The 1987 production figures for cultured marine organisms in Scottish waters are presented in the Table below:

SPECIES	SCOTLAND 1987	1988
Atlantic Salmon	12,721 to	17,951to
Rainbow Trout	*3,207 to	,709 to
Turbot	0,100 t	--,---
Shellfish	not available	,914 to

* includes freshwater production in 1987

At present Salmon farming is predominantly carried out in Scotland at 244 (185 in 1987) sea sites and 14 (11 in 1987) land based farms. Some 21 million smolts (13 million in 1987) were placed in sea water from companies operating 176 freshwater sites (131 in 1987). The production of Atlantic salmon is continuing to increase as previously reported (41% over 1987).

In England and Wales most finfish culture, rainbow trout, takes place in freshwater but onshore marine farming units have been developed for salmon, trout and turbot.

With respect to the finfish industry in Scotland, there are a number of ecological investigations currently in progress. These include; (a) continuing study on the recovery of mollusc populations following the restrictions placed on the use of TBT; (b) the ecological effects of chemical treatments, e.g. delousing agents. (c) studies to determine the holding capacity of sea lochs.

Country Report Canada

by

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and

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Biological Science Branch
DFO, Bedford Institute of Oceanography
Dartmouth, N.S.

Atlantic Canada

Mariculture on Canada's eastern sea board has expanded rapidly in the last twelve months Production has more than doubled from an annual total production of 3,055 tonnes in 1987 to 6,537 tonnen in 1988 (exclusive of cod production, which was not reported in hte 1987 statistics). Cod with its present production of 450 tonnes is anomalous in that seed for this industry is derived from fish in the wild cod fishery which are too small to be marketed. The other species are either maintained in culture for their full life cycle or are gathered at the time of settlement out of the plankton.

Pacific Canada

Salmon production on the west coast is growing exponentially. This growth is expected to continue next year with 1989 salmon production projected to be in the range of 14,000 to 16, 000 tonnes. There appears to be excess smolt supply in the industry. In psite of late purchases of smolts to replace the 500,000 fish lost to storm damage in early 1989 some smolts will pprobably have to be destroyed due to a lack of buyers.

Oyster above table does not show the dramatic shift in type of production occurring in the industry. The industry is moving from producing large (120 oysters to the gallon) beach grown oysters to producing smaller (250 oyster to the gallon) suspended culture oysters for the half-shell restaurant trade. In consequence inspite of reduced production, where as only 200,000 half-shell oysters were produced in 1985, in 1988 over 500,000 half-shell oyster were marketed.

Projected figures for 1989 oyster production are uncertain. The figure quoted in the graph below is what might be expected from past growth in the industry. However, there has been an inconfirmed report of one company seeding 7,000,000 oysters for the half-shell market. If this is accurate and the company can adequatetly maintain the oysters, 1989 production could be as high as 16,000 tonnes. It seems more probable that predation and the abundance of natural feed will result in more lower level of production.

Research priorities

In 1988 environmental research focussed on industry support by; development of techniques for the detection of antibiotic residues in Pacific salmon, examination of the effect of copper antifouling paints on bioavailability of copper in the environment and in nearby fish and shellfish, monitoring water quality in the aquaculture environment, expanding the extent of the industry based early warning system for dangerous phytoplankton, and examining oxygen conditions in a nd around salmon farm sites.

The 1989 research priorities are expected to concentrate more on the interaction of aquaculture and wild fisheries, and on the potential effects of drugs used in mariculture.

Production Trends

Aquaculture production data for Atlantic and Pacific Canada are presented in the figures below:

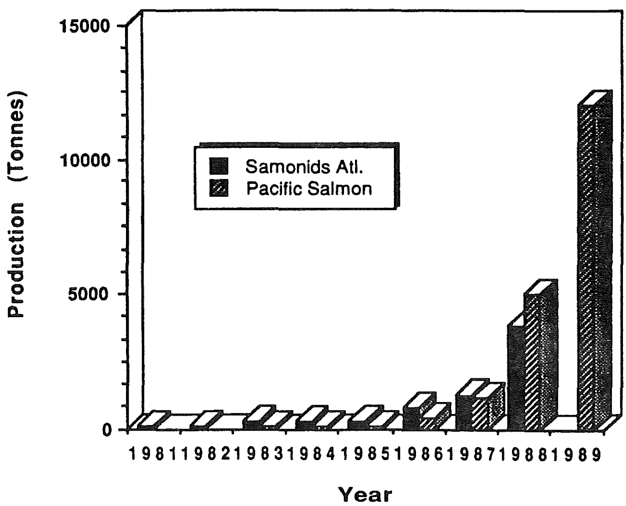

Figure 1. Production trends in Canadian marine salmonid aquaculture (1989 estimates for the west coast included)

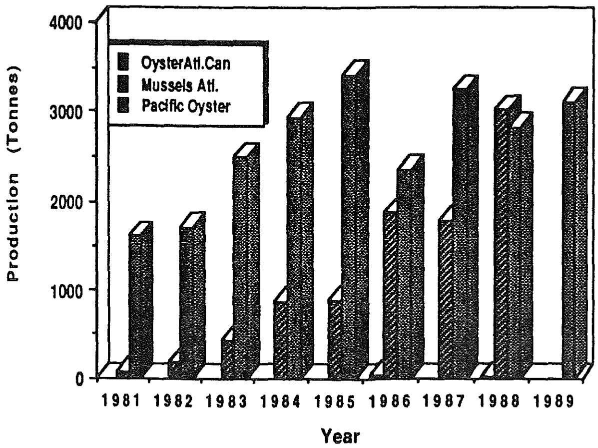

Figure 2: Production trends in Canadian marine bivalve aquaculture (1989 estimates for the west coast included)

STATUTORY INSTRUMENTS

1988 No. 1218

FISH FARMING

The Environmental Assessment (Salmon Farming in Marine Waters) Regulations 1988

Made	*12th July 1988*
Coming into force	*15th July 1988*

The Secretary of State, being a Minister designated(a) for the purposes of section 2(2) of the European Communities Act 1972(b) in relation to measures relating to the requirement for an assessment of the impact on the environment of projects likely to have significant effects on the environment, in exercise of the powers conferred on him by the said section 2 and of all other powers enabling him in that behalf, hereby makes the following Regulations, a draft of which has been laid before and approved by a resolution of each House of Parliament:

Citation, commencement and application

1.—(1) These Regulations may be cited as the Environmental Assessment (Salmon Farming in Marine Waters) Regulations 1988 and shall come into force on the third day following the day on which they are made.

(2) These Regulations apply in any case where an application for consent for salmon farming in marine waters is received by the Crown Estate Commissioners on or after 15th July 1988.

Interpretation

2. In these Regulations, unless the contrary intention appears–

"document" includes a map, diagram, illustration or other descriptive matter in any form and also includes where appropriate a copy of a document;

"environmental information" means–

(a) any environmental statement required to be provided by these Regulations;

(b) any representations made by any authority, body or person required by these Regulations to be invited to make representations or consulted; and

(c) any representations duly made by any other person about the likely environmental effects of the proposed development;

"environmental statement" means such a statement as is described in Schedule 1;

"inland waters" means waters within Great Britain which do not form part of the sea or of any creek, bay or estuary or of any river as far as the tide flows;

"local planning authority" means any authority which is a local planning authority for the purposes of the Town and Country Planning Act 1971(c);

"marine waters" means waters within the seaward limits of the territorial sea adjacent to Great Britain, other than–

(a) inland waters; and

(b) waters within the jurisdiction of a local planning authority;

(a) S.I. 1988/785.
(b) 1972 c.68.
(c) 1971 c.78.

"planning authority" means a district planning authority or general planning authority as defined in section 172(4) of the Local Government (Scotland) Act 1973(a);

"river purification board" means a river purification board established under section 135 of the Local Government (Scotland) Act 1973(b);

"salmon farming" means keeping live salmon (whether or not for profit) with a view to their sale or to their transfer to other marine waters; and

references to Schedules are references to Schedules to these Regulations.

Prohibition on the granting of consent without environmental information

3.—(1) The Crown Estate Commissioners shall not grant consent for salmon farming in marine waters where the proposed development will be likely to have significant effects on the environment by virtue *inter alia* of its nature, size or location unless they have taken into consideration environmental information in respect of the proposed development.

(2) For the purposes of paragraph (1), a proposed development shall only be taken to be likely to have significant effects on the environment by virtue *inter alia* of its nature, size or location where the Crown Estate Commissioners consider that this is the case.

Application for consent

4.—(1) An application for consent for salmon farming in marine waters shall be accompanied by–

(a) a plan showing the location and extent of the site of the proposed salmon farm;

(b) a brief outline of the proposed scale of production and the equipment to be installed on site; and

(c) a statement of the proposed servicing methods and of any intended development on land.

(2) On receipt of any such application–

(a) the Crown Estate Commissioners shall consider whether the proposed development is one to which the prohibition in regulation 3 applies;

(b) where the Crown Estate Commissioners consider that the applicant has not provided them with sufficient information to enable them to form an opinion, they may ask him for further information;

(c) where it appears to the Crown Estate Commissioners that an application for development is an application to which the prohibition in regulation 3 applies, they shall within 6 weeks beginning with the date of receipt of the application notify the applicant in writing of their view and that without consideration of environmental information they may not grant consent;

(d) in coming to a view as to whether consideration of environmental information is required the Crown Estate Commissioners shall consult such of the authorities, bodies or persons mentioned in Schedule 2 as they consider appropriate.

Provision of information for environmental statement

5. Where the Crown Estate Commissioners are of the view that the application is one to which the prohibition in regulation 3 applies they shall–

(a) inform such of the authorities, bodies and persons mentioned in Schedule 2 as shall be appropriate according to the circumstances mentioned therein–

(i) of the application and of the requirement for an environmental statement; and

(ii) that they may be required to make available to the applicant, in accordance with regulation 6(1), any information in their possession which he or they consider relevant to the preparation of an environmental statement; and

(b) inform the applicant–

(i) of what they have done under paragraph (a);

(ii) of their view that he should provide an environmental statement; and

(a) 1973 c.65.
(b) Section 135 was amended by the Control of Pollution Act 1974 (c.40), Schedule 4.

(iii) that he shall supply the authorities, bodies and persons mentioned in Schedule 2 with such further information about the proposed development as they may request.

Provision of relevant information

6.—(1) Subject to paragraph (2), any authority, body or person informed by the Crown Estate Commissioners under regulation 5 that a person has applied for consent for a development to which the prohibition in regulation 3 applies shall, if requested by the applicant, or may, without any such request, enter into consultation with him with a view to ascertaining whether they have any information in their possession which he or they consider relevant to the preparation of the environmental statement and shall make any such information available to him.

(2) Nothing in paragraph (1) shall require the disclosure of any information which the body concerned are entitled or bound to hold in confidence.

Publicity for environmental statement

7.—(1) When an environmental statement is submitted, the Crown Estate Commissioners shall publish as soon as possible a notice in a newspaper circulating in the locality nearest to the proposed development and in the Edinburgh Gazette, or London Gazette as the case may be, stating–

(a) where the application and the environmental statement may be inspected, which shall be at a Post Office in the locality nearest to the proposed development;

(b) the address at which copies of the application and the environmental statement may be acquired;

(c) the cost of a copy of the environmental statement;

(d) that representations in writing may be made within a specified period being not less than 28 days from the date of the said notice.

(2) Where the Crown Estate Commissioners are required to publish a notice in accordance with paragraph (1) of this regulation, the applicant shall pay the cost to be incurred by them in arranging such advertisements.

Consultation on environmental statement

8.—(1) Where the Crown Estate Commissioners receive an environmental statement relating to an application to which the prohibition in regulation 3 applies, they shall consult the authorities, bodies and persons mentioned in Schedule 2, according to the circumstances mentioned therein, about the environmental statement and such other persons, groups or bodies as they consider appropriate.

(2) Where an applicant submits an environmental statement to the Crown Estate Commissioners, he shall supply them with enough copies of the environmental statement or parts thereof to enable them to comply with paragraph (1) of this regulation and one additional copy.

(3) Where, under this regulation, the Crown Estate Commissioners consult any authority, body or person–

(a) they shall give not less than 28 days' notice to such authority, body or person that environmental information is to be taken into consideration; and

(b) they shall not grant consent for the development to which the environmental information relates until after the expiration of the period of such notice.

(4) Where any authority, body or person which the Crown Estate Commissioners are required to consult under this regulation consider that consultation with them is not required in respect of any environmental statement relating to any case or class of case, or relating to any specified area they shall so inform the Crown Estate Commissioners in writing and notwithstanding the foregoing provisions of this regulation the Crown Estate Commissioners shall not be required so to consult them.

Further information and evidence relating to environmental statements

9.—(1) The Crown Estate Commissioners, when dealing with an application in relation to which an environmental statement has been provided, may in writing require the applicant to provide such further information as may be specified to enable the application to be determined, or concerning any matter which is required to be dealt with in the environmental statement; and where in the opinion of the Crown Estate Commissioners–

(a) the applicant could (having regard in particular to current knowledge and methods of assessment) provide further information about any matter mentioned in paragraph 3 of Schedule 1; and

(b) that further information is reasonably required to give proper consideration to the likely environmental effects of the proposed development,

they shall notify the applicant in writing and the applicant shall provide that further information.

(2) The Crown Estate Commissioners may in writing require to be produced to them such evidence, in respect of any environmental statement which it falls to them to take into consideration, as they may reasonably call for to verify any information it contains.

Intimation of decision

10. Where the Crown Estate Commissioners have decided an application to which the prohibition in regulation 3 applies, they shall inform the applicant and all authorities, bodies or persons consulted under regulation 8 of their decision, and of any conditions attached to it.

Charges

11.—(1) A reasonable charge reflecting the costs of printing, copying and distribution may be made to the public for copies of an environmental statement made available to them under regulation 7 and for copies in excess of one copy for each authority, body or person consulted under regulation 8.

(2) An authority, body or person entering into consultation under regulation 8, having been requested to do so, may make a reasonable charge reflecting the costs of making available information which they had in their possession.

Malcolm Rifkind
One of Her Majesty's
Principal Secretaries of State

St. Andrew's House, Edinburgh
12th July 1988

SCHEDULE 1

Regulations 2 and 9

ENVIRONMENTAL STATEMENTS

1. An environmental statement comprises a document or series of documents prepared by the applicant and providing, for the purpose of taking into consideration environmental information in respect of a proposed development, the information specified in paragraph 2 (referred to in this Schedule as "the specified information").

2. The specified information is–

(a) a description of the proposed development, comprising information about the site, and the design and the size or scale of the proposed development;

(b) the data necessary to identify and assess the main effects which that development is likely to have on the environment;

(c) a description of the likely significant effects, direct and indirect, on the environment of the proposed development, explained by reference to its possible impact on–

A. human beings;
B. flora;
C. fauna;
D. soil;
E. water;
F. air;
G. climate;
H. the landscape;
I. the inter-action between any of the foregoing;
J. material assets;
K. the cultural heritage;

(d) where significant adverse effects are identified with respect to any of the foregoing, a description of the measures envisaged in order to avoid, reduce or remedy those effects; and

(e) a summary in non-technical language of the information specified above.

3. An environmental statement may include, by way of explanation or amplification of any specified information, further information on any of the following matters–

(a) the physical characteristics of the proposed development, and any land-use requirements during the construction and operational phases;

(b) the main characteristics of any production processes proposed, including the nature and quality of the materials to be used;

(c) the estimated type and quantity of any expected residues and emissions (including pollutants of water, air or soil, noise, vibration, light, heat and radiation) resulting from the proposed development when in operation;

(d) (in outline) the main alternatives, if any, studied by the applicant and an indication of the main reasons for his choice, taking into account the environmental effects;

(e) the likely significant direct and indirect effects on the environment of the proposed development which may result from–

(i) the use of natural resources;

(ii) the emission of pollutants, the creation of nuisances, and the elimination of waste;

(f) the forecasting methods used to assess any effects on the environment about which information is given under sub-paragraph (e); and

(g) any difficulties, such as technical deficiencies or lack of know-how, encountered in compiling any specified information.

In paragraph (e) "effects" includes secondary, cumulative, short, medium and long-term, permanent and temporary, positive and negative effects.

4. Where further information is included in an environmental statement pursuant to paragraph 3, a non-technical summary of that information shall also be provided.

SCHEDULE 2

Regulations 4, 5 and 8

BODIES TO BE CONSULTED

1. Any planning authority or any local planning authority whose area adjoins the area of marine waters where the proposed development is to be situated.

2. (a) The Secretary of State for Scotland and the Countryside Commission for Scotland, where the proposed development is to be situated in an area of marine waters adjoining Scotland;
   (b) the Secretary of State for the Environment or the Secretary of State for Wales or both as appropriate, and the Countryside Commission, where the proposed development is to be situated in an area of marine waters adjoining England or Wales.

3. The Nature Conservancy Council.

4. Any river purification board whose area comprises or adjoins the area of marine waters in which the proposed development is to be situated.

5. Any water authority in England and Wales whose area comprises or adjoins the area of marine waters in which the proposed development is to be situated.

6. Where the proposed development is to be situated in the marine waters landward of a line drawn between Burrow Head and St Bees Head–
   (a) both the North West Water Authority and the Solway River Purification Board; and
   (b) both the Secretary of State for Scotland and the Secretary of State for the Environment and the Countryside Commission for Scotland and the Countryside Commission.

EXPLANATORY NOTE

(This note is not part of the Regulations)

The Regulations implement for Great Britain Council Directive 85/337/EEC (O.J. No. L175, 5.7.85, p.40) on the assessment of the environmental effects of certain projects in respect of salmon farming in marine waters.

The Regulations provide that decisions on whether consideration of environmental information in respect of any particular application for salmon farming in marine waters is required shall be taken by the Crown Estate Commissioners.

Regulation 3 provides that the Crown Estate Commissioners shall not grant consent for salmon farming in marine waters where the project is likely to have significant effects on the environment, without taking into consideration environmental information in respect of the proposed project.

Regulation 4 provides procedures for allowing the Crown Estate Commissioners to come to a view on whether consideration of environmental information is required.

Regulation 5 provides for relevant bodies to be informed of the need for consideration of environmental information.

Regulation 6 provides that any bodies with relevant information in their possession shall make it available to the applicant.

Regulation 7 provides that the environmental statement shall be publicised through press advertisement and made available for public inspection, with the opportunity for representations to be made.

Regulation 8 provides that the Crown Estate Commissioners shall consult the bodies mentioned in Schedule 2 about the environmental statement.

Regulation 9 enables the Commissioners, when taking into consideration environmental information, to require further information or the verification of information.

Regulation 10 requires the Crown Estate Commissioners to make known their decision in cases involving consideration of environmental information.

Regulation 11 provides that a reasonable charge may be made for making available copies of the environmental statement and of any relevant information in the preparation thereof.

Schedule 1 sets out the information that is required in an environmental statement and Schedule 2 lists the bodies to be consulted by the Crown Estate Commissioners under the Regulations.

B.C. Reg. 470/88 Deposited December 2, 1988
O.C. 2164/88

Waste Management Act

AQUACULTURE WASTE CONTROL REGULATION

Interpretation

1. In this regulation

"dry weight" means the gravimetric determination of the total residue left in a vessel after drying to a constant weight at a temperature of 103° to 105° C;

"mortalities" means finfish that have died from disease, plankton bloom, stress or other similar causes and that are not marketed for human consumption;

"finfish netcage aquaculture operation" means a finfish netcage aquaculture operation located in tidal salt water at a site that is leased or licensed under section 35 or 36 of the *Land Act*;

"operator" means a person who owns a finfish netcage aquaculture operation and includes a person authorized by the owner to act as the operator.

Exemptions

2. A person who carries out a class of operation, activity, industry or work referred to in section 3 is exempt from the requirement to hold a permit or approval under the *Waste Management Act* in respect of the class if he meets the conditions and circumstances set out in section 3 in respect of the class and if he provides to the Regional Waste Manager, on his request, information that allows him to determine the existence and extent of the discharge of waste.

Classes

3. The classes of operations, activities, industries or works referred to in section 2 are:

(a) the introduction of finfish feed or finfish fæces to tidal salt water from a finfish netcage aquaculture operation where

(i) the total feed usage does not exceed 630 tonnes dry weight per year,

(ii) the use, storage and disposal of materials and wastes on or off the finfish netcage aquaculture site is carried out in a manner that minimizes odour, risk of spillage and attraction of and impact on wildlife,

(iii) the operator complies with a monitoring program, stipulated by the manager, that allows the manager to determine

(A) the existence and extent of environmental impact caused by the operation,

(B) whether finfish aquaculture is likely to result in any alteration, disruption or destruction of wildlife, finfish, shellfish or their habitat,

(C) whether discharges of sewage are disposed of in a manner that causes pollution, and
(D) whether therapeutants, anesthetics, disinfectants, pesticides, wood preservatives, antifouling agents and other similar materials are stored and applied in a manner that causes pollution,

(iv) the operator complies with any requests by the manager for information in addition to the monitoring program under subparagraph (iii) for the purpose of allowing the manager to determine the matters set out in subparagraph (iii) (A) to (D),
(v) the operator notifies the manager regarding changes to the aquaculture operation that may affect the kind or quantity of the wastes disposed of or discharged,
(vi) pollution is caused by the aquaculture operation, and the operator, as soon as possible in the circumstances, reports the pollution to the manager and takes appropriate action, as directed by the manager, to ameliorate the pollution and prevent its recurrence, and
(vii) the operator prepares a contingency plan which documents procedures to be followed during a major fish kill, including the method of disposal of mortalities, and obtains the manager's approval to the plan;

(b) the introduction from a finfish netcage operation to tidal salt water of treated domestic sewage that is
(i) produced in a quantity that is less than 2.5 m^3 per day,
(ii) produced from premises located on the foreshore adjacent to tidal saltwater, or on tidal saltwater,
(iii) collected and treated in a septic tank that provides at least 2 days retention time for the sewage,
(iv) discharged at a depth greater than 15 m below hydrographic chart datum within the boundaries of the operation, and
(v) located more than 125 m from commercial or recreational shellfish resources.

Offence and penalty

4. (1) Every person who
(a) makes, participates in, assents to or acquiesces in the making of false or deceptive statements in a return, record or answer filed or made as required by or under this regulation,
(b) omits, or assents to or acquiesces in the omission of, entries in records required by or under this regulation, or
(c) in any manner evades or attempts to evade compliance with this regulation

commits an offence and, in addition to any penalty otherwise provided, is liable on summary conviction to a penalty not exceeding $2 000.

(2) No person commits an offence under subsection (1) (a) or (b) if he did not know that the statement or entry was false or deceptive and, in the exercise of reasonable diligence, could not have known that the statement or entry was false or deceptive.

[Provisions of the *Waste Management Act* relevant to the enactment of this regulation: section 35]